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Dunedin Astronomical Society

ESSAYS ON THOUGHTS AND WORLDS

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Photo by Campbell G. Begg

JOHN CAMPBELL BEGG

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JOHN CAMPBELL BEGG

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DEDICATION

As this book has been prepared with a thought for my interested descendants I should like to include in it loving mention of their co-parent, my late wife Agnes, to whose memory, with abiding affection, I dedicate the volume.

J. C. B.

INTRODUCTORY

This collection of essays is presented with modesty, for certainly I have no fantastic idea of a world thirsting for such fare. Philosophy is not a very popular subject, and least so, perhaps, in its role of theory of knowledge, to which department many of the ideas in these essays belong. My motive in making the collection, as far as I can diagnose it, has been twofold: first there is a certain fatherly satisfaction in seeing and possessing a conjoined presentation of some selected thoughts and themes elaborated at intervals over a fairly long period, some of these having found expression in various journals and publications dated about the time of their composition: secondly, I like the prospect that such of my family and friends as possess any curiosity about the subjects dealt with, or my attitude to these subjects, should have an opportunity of access to this record in handy compass. Like most books—and maybe quicker than most—this one will doubtless hasten towards oblivion, but it may fulfil at least a temporary function. Over and above the dual purpose mentioned, I should be happy to think that if the philosophical articles come under the observation of any students or others who may be trying, as I have done, to probe below the obvious and common grounds of knowledge and belief, my reflections may contribute some modicum of assistance, or at least some basis of comparison with their own thoughts. A similar remark applies to the astronomical and general articles, although there I am conscious that any originality may lie chiefly in the mode of presentation rather than in the substance.

The philosophical essays have perhaps the greatest need of a few preliminary remarks, because philosophy has tied the human mind in knots ever since discussions in this domain began to fascinate the imagination of men. With the advance of time many heat-generating and futile controversies have become obsolete, but it can by no means be claimed that difficulties and mysteries have been eliminated,—difficulties which science in its working tasks can

ignore, and indeed must often ignore in the interests of economy of thought. These difficulties remain with those who know that science, notwithstanding its astounding achievements, founds itself upon varying assumptions which do not penetrate to bedrock or the limits of human discernment. Philosophers, at the other extreme, have indulged in wild speculations. It is wise, and I think possible, to recognize inevitable limits to human knowledge, although these limits reach beyond the realms of ordinary science with its practical boundaries. Intellectual achievement may find its goal in the most consistent scheme that will function as a framework within which philosophy, science and common sense can move most smoothly and effectively. Such a framework may not be unitary and complete in itself; indeed it never can be. The enclosing boundary line curves round, but, even when it seems to join up neatly, there is inevitably an unassimilated and excluded region ready with a rebuff to the over-ambitious philosopher trying to squeeze it within the boundary. I amused myself many years ago by composing the following fable in blank verse, aimed at those philosophers who hope to embrace the whole of being, including themselves, in a unitary system. The lines are crude but, I believe, expressive of a truth. Here they are:

The Tragedy of a Philosophical Python

A warning to philosophers who think to comprise the entire Universe of Being (including themselves) in a single system.

Now the serpent was more subtle than any beast of the field.
—Genesis.

A brooding old python once said
My tail is so far from my head,
To say where I am would be simply a sham
While to dozens of places I spread.
This unphilosophical plight
I must hasten at once to put right;
Besides, in a "spar" not to know "where 'e are"
Is to cancel one's chance in the fight.
So, making extremities meet,
His tail he proceeded to eat;
And slithery licking preventing all sticking,
The tail glided into retreat.
The circle contracted apace
As the snake, with a smile on his face,
Said soon we shall see how I'm going to be
In a single particular place.
Just then a mysterious pain
Shot through his whole system amain;

It seemed in his head, but instantly spread
Round his tail to his head once again.
The pain, in a quandary quite,
Could not tell on what point to alight;
But missing location in rapid rotation
Pursued its precipitous flight.
Then whirligig forces arose,
Which brings my sad tale to a close;
For sudden there rang a shattering bang;
The python was meat for the crows!

Hints have not been wanting that some philosophers have envisaged the possibility of a complete blow-out, which could leave them, like Othello, with occupation gone; but such an outcome can well be avoided. My cautionary tale does not discredit the ample field which philosophy can usefully occupy, as is being more and more widely recognized by the present generation of thinkers, including working scientists. I hope my small contribution may prove tolerably clear and consistent, although any claim to completely static outlook over the greater part of a lifetime could probably argue obstinacy or blindness rather than a virtue of consistency.

Prominent in the essays is the theme that knowledge, at least complex knowledge, looks out, not on a world of fixed and self-existing entities, but rather on a realm shaped and coloured by the character of our sense perception and the forms of intellect. This is in line with the philosophy of Immanuel Kant, but greater emphasis is now laid on the possibility of diverse scientific worlds resulting from selective variation in the formative concepts employed—just as the vibrant ether round a receiving set might be construed as jazz, classical music, or an expository lecture, according to the optional twist of a tuning knob. An errant turn might produce squeals and chatter which we could attribute to the receiving set, while the various coherent settings would be thought to reveal an external objectivity.* A former generation would no doubt be shocked by this cavalier treatment of a world which was confidently supposed to rest secure in its identity whatever might be our feeble efforts to discern it; and to many people our altered view may still seem incredible and subversive of a sane

* It is suggested that some readers may find a better understanding of what follows from this point after reading the Essays.

outlook. This attitude is not undeserving of sympathy, and I should like to say that, while logic and correct philosophy of science hold an unquestionable field of usefulness, and must not swerve in the interests of prejudices and prepossessions, these disciplines have little or no prospect of attaining complete satisfaction in a quest which must confront the primal mystery of existence equally at the commencement and at the end of their labours. The fascinating temple of reason with all its co-opted allies tends to isolate itself as it were on an island round which the swirling tides of life surge on to objectives set by primal inner impulses. This has been cited as a motif for the rather wild excursions of surrealist art and existential philosophy in direct, non-logical vision. It must be admitted that complete relativism leaves us with the question why our actual experience is as it is and not otherwise. It is this stream of consciousness, that science, even physical science, tries to interpret rather than to fix the accompanying entities, which are so prone in successive epochs to present changing faces, and indeed to pass completely into the discard. This has happened to such things as phlogiston, caloric, gravitational force, and even matter itself as formerly understood. Science implies a disciplined progress rather than a straight aim at perfection; finality cannot be expected, or, indeed, imagined. It is an intellectual weapon to help out what is lacking in instinct and intuition, but it cannot operate without a boundary against the unknown. Omnicience would not require science any more than a Marathon racer needs a crutch, and, being unnecessary, science would be no more relevant than such a crutch—or indeed than a witch's cauldron. Omniscience, however, and also omnipotence, although functioning naturally as terms of wonderment and worship, are scarcely capable of consistent logical analysis, either separately or in conjunction. Such terms participate in all the difficulties surrounding the concept of infinity, which, notwithstanding the achievements of modern mathematicians, still stands aloof from complete comprehension as a primitive notion. Present trends and concepts of science and mathematics have been enormously fruitful, but it would be unwise to imagine them as final,

or, indeed, as but a phase in ever-changing fundamental instruments of the mind by which we assess our environment. Attacks are already being made in influential quarters against our spatio-temporal prepossessions, and even on the sufficiency of mathematical explanation.

As to the originality of ideas expressed in this book, probably none of them could claim originality in the sense of complete novelty, and many of the points raised are matters of common discussion. But what constitutes originality? We are all plagiarists from the dictionary and from the alphabet; it is only a matter of arrangement! Analogues can be found in earlier writings for most emergent notions, and, as for the germ of ideas, there is probably no retrospective halting place short of the Garden of Eden. All writers and thinkers are beholden to the philosophers whose work has become a traditional asset; it is not possible adequately and correctly to pay individual tributes. Personally I should give full acknowledgment of this great legacy, and also of my debt to contemporary philosophers, many of whom it has been impossible to name because their work has simply intertwined with general discussions. This help does not in all cases imply the forestalling of my own thoughts, but consists in giving these thoughts support and alternative forms, often from a much greater fund of scholarship than I have at my disposal. I must not forget my college teacher, Professor Wm. Salmond, and in the modern movements I should specially name A. N. Whitehead, Bertrand Russell, and that wonderfully profound and placid thinker who has had such general recognition by Western philosophers, Ernst Cassirer. I have been privileged to hear lectures and to have some personal interviews with these men, so very different from each other in many ways, but all with vital and original contributions to the thought of this century. These tributes do not, of course, imply adherence to all the tenets of such diverse minds, which would be obviously impossible. The logical empiricists, too, have been stimulating and very influential since Wittgenstein. It is not easy to ascribe priorities. I have found many tenets of this school (though by no means all) in accord with mine, but there is ample room for novelty in presentation

and illustration. I should frankly admit, what will be obvious to critics, that many of the points raised in the essays lack that expansive development which would exhibit their implications in fuller contexts; but I think I have touched on a fairly wide range of significant issues which in advancing years have become prominent in philosophical discussions.

In conclusion I should like to mention two matters in which I have elicited little or no support from contemporary philosophers, although I believe them to be valid and important—in one case for theoretical reasons, in the other because it seems fundamental to human relations. The first is the almost irresistible, but logically weak, urge to allow contiguity in space and time to condition our apprehension of entities, or individual things. An object, such as a brick, is composed of a group of properties such as redness, hardness, rectangularity, etc. This, at least, is a commonplace in the controversy between realism and idealism; but a consideration generally ignored is the preferential grouping of properties on the score of contiguity. I have referred to this without elaboration in " The Status of Physical Concepts ". Consider why it is that we group the redness of the brick with other properties mentioned (to compose an entity) rather than with anything else in the Universe—say the roundness of some ball far removed from the particular brick, or the softness of a distant feather. Of course there is a practical reason for integrating qualities adjacent in space, especially overlapping qualities, to form discreet bodies, but one may well ask if such a predilection is anything more than a bias of our comprehending faculties. Could the case not possibly be otherwise? We do not think it anomalous to assign a unity to the British Empire regardless of its far-flung geography. Contiguity in time can raise a similar problem, but reference to this point in regard to either space or time has been rarely found in philosophical discussions. A recent exception (and not to be considered in any way lineal to my own earlier recorded suggestion) is in the work of Professor Nelson Goodman of Pennsylvania, where the linking of concept constituents is examined.

The second matter is that dealt with in the article "Time Order in Minds". I can scarcely imagine a more vital human question than that of the actual presence or contemporaneousness of friends in some sense quite independent of physical law, which we know to be so variable and relative to our mode of apprehension. I have made the point in my brief article, and there is no need to repeat. That we can bring no test other than physical to determine mental simultaneity in different individuals does not, I feel sure, make the quest meaningless, but the compelling recognition of some meaning is itself powerful to overthrow the sufficiency of the physical test.

I shall not encumber this Introduction with any attempt to elucidate the non-philosophical articles which, I must hope, will be self-explanatory.

A few short passages are common to more than one of the essays, having been repeated as relevant to the new contexts.

Finally, my thanks are due to the following organizations which have agreed to my re-publishing articles previously contributed to their journals: The Royal Institute of Philosophy (England), The Mind Association (England), The Australasian Association of Psychology and Philosophy (Sydney), and the Otago Daily Times and Witness Co. (New Zealand).

JOHN C. BEGG.

CONTENTS

I.

THOUGHTS AND WORLDS*

There is nothing either good or bad but thinking makes it so.
—Hamlet.

THE above quotation seems morally subversive, but I do not wish to discuss the influence of thought on values. Rather I am concerned with the influence of thought on entities, or, by aggregation of entities, on worlds. The title of this article is used also for the joint collection of essays comprising this little book. Such a general title may not seem very revealing as to the nature of the matters dealt with, but it has a certain appropriate significance in respect to the philosophical sections in which the reciprocity between thought and entity is elaborated in various ways. The title is also wide enough to serve as a blanket cover for the sundry topics discussed.

A commentator on a book by the rather opaque, if profound, German philosopher, Hegel, is said to have advised his students to meditate for an hour on the opening words THERE IS before reading further in the text. One could forgive an impatient reception of this advice concerning a perfectly obvious phrase; but later reflection might reveal that an hour is all too short a time to grasp the implications of an idea which has baffled so many thinkers throughout the entire history of philosophy. The simple word " is ", with its participial form " being ", has posed endless problems. Grammarians have found it necessary to give the verb " to be " unique treatment in syntactical rules, and philosophers have groped rather pathetically, and certainly inconclusively, in and around the notion of being and its correlates such as " thing ", " entity ", " reality ".

Worlds seem to be composed of things; but what is a thing? One might answer as Augustine did to the question: what is time? " If you don't ask me I know: if you ask me I can't tell you." Is Macbeth's " air drawn dagger " a thing? What about " the theory of relativity ",

* Composed for this volume.

" the scent of a rose ", " the beauty of a landscape ". No doubt we could classify these expressions as composite nouns, more or less abstract. In contrast with such terms are " house ", " book ", " dog ", etc. Closer study, however, may show that all terms are in a measure abstract, and none are self-sufficient, but I shall not elaborate that point now. Suffice it to note that so many of the terms and names in common use are dependent on abstract thought for their occurrence. We thus see that thought and things are related in a very close alliance. What would become of the theory of relativity, the beauty of a landscape, the area of a triangle, if the contribution of mind were withdrawn? Thus it becomes very difficult to assign thinghood as an independent attribute with consistent assurance.

In the course of long history and struggle for existence a tendency has developed to give special status of reality to material objects: we are apt to think that these have a special claim to thinghood—abiding objects. But idealist philosophers such as Berkeley have demonstrated that mind is essential to the constitution of even the grossest material object. Immanuel Kant, the very influential philosopher of last century, declared that our intellects interpose such a screen between us and any object of observation that we could not be imagined to make contact thus with anything in its native character. He said that the mind of man was interned, as it were, in an island surrounded by the estranging sea, and isolated from all other realms of being. Intellect, far from forming a bridge of communication with things as they are, thus seems rather to constitute a distorting medium to delude us with plausible, but utterly unreliable, reports of regions beyond our ken. Thought and thing are thus experienced in an inextricable tangle, apparently beyond the wit of man to unravel.

It is true that common sense has rebelled against this radical sceptism, and even among philosophers who have been driven by logic to accept it are to be found some who recognize the right of practical reason to override formal logic and accept the more natural view of the world known to us as something outside ourselves and full of distinguishable objects of undoubted validity. Supplementing the

overwhelming and intuitive urge to believe in such objects, and act accordingly, there have been eminent thinkers, such as the Scottish Thomas Reid and the Cambridge philosopher, G. E. Moore, who on logical grounds vehemently reject and discredit the arguments of the idealists, their central contention being that the primitive impact of external things upon our minds is not only basic but essential to the very thoughts of the philosophers themselves who claim by these thoughts to overthrow the objects to which they owe the ammunition for their attack.

Critical philosophers of more recent schools claim to avoid dogmatism, either positive or negative, in regard to what is real, but point out that when terms are in general use their " denotation ", or that to which they apply, is governed by the terms themselves, which, in turn, are arbitrary and optional. If by general consent we apply the description " thing " or " real " to certain recognized and regular appearances, or combinations thereof, then such designations are final and automatic in applying to the objects in question. The status of thinghood or reality is not conferred by some presiding arbitrator beyond our ken, but is a matter of free election when we devise the term and apply it to the appearances in question, whether these appearances be tin tacks or the most elusive abstraction, provided the latter can achieve common recognition, as, for example, do mathematical functions. But perhaps I should note here that an influential section of the so-called logical positivists—those who adhere to the view just stated—regard " physicalism " as the proper basis of thought, although I do not see how they can on principle differentiate in favour of material objects. Such differentiation must by their own showing depend in any case upon convention and convenience, and by ordinary usage, coverage of the terms " thing " and " real " passes far beyond the physical realm.

My purpose in citing this modern school of critics which, though divided internally on many points and subject to a good many limitations, has certainly cleared up numerous bogeys, is to show how our loose, everyday ideas of the world and its contents are not sacrosanct or final. While

legitimately clinging to our useful and proved view of things and thoughts, we must allow that in them we have not necessarily any continuing city, but a realm in which invading science and changing purposes may recast our habitual concepts and values. Vague distant thoughts, or, indeed, quite unforeseen novelties, may become important realities (e.g. electrons and vitamins), while strongly established substances (as phlogiston, caloric and electricity in its former guise) may be abolished or fade from consideration. This applies perhaps even more manifestly to the metaphysical, social and cultural realms. Monads and quidities go out of fashion, or at least have a radical face lift.

Whigs and Tories may cease to be recognisable as such; and so with nations and geographical units. All this adds up to the same story—that purposes and consequent thoughts of men are reflected in the objective entities and institutions which emerge and engage our attention.

It will be obvious that this theme can be, not only expanded as a theory, but also applied extensively in all departments of science, culture and progress. Indeed the future of mankind is linked closely with interactions and mutations in the correlative realms of thoughts and things which react so closely the one upon the other. Some may incline to assign the initiative to thought—as in the motto at the head of this article—while many discern a compelling force in a region beyond the control of our most ingenious devices: " There's a divinity that shapes our ends, rough hew them how we will." At this point I shall not attempt a discussion on these opposing views. Suffice it to have pointed out that changes in our apprehension of (and therefore the apparent nature of) even the familiar world can come through variable thought, and this without denying that cataclysms, or, indeed, subtle and unimagined influences may react on thought and force it into subjection.

Before concluding it is incumbent on me to point out that the theme indicated in rough outline has been the subject of very extensive discussions and literature throughout the academic world. The implications have been sorted out and criticized in detail with such intensive emphasis on sundry aspects that one might be pardoned for suspecting

that the unbiased overall judgment may be somewhat prejudiced by the reflex of special pleading. Actually there is much confusion, not only in opinion but in the assessment of the problems. In the words of Pope's Iliad:

> To few, and wondrous few, has Jove assigned
> A comprehensive, all considering mind.

As I have indicated above, the theme of thought-thing reciprocity underlies some of my essays and I have attempted to interweave it as seemed relevant to the particular exposition in hand. May I entertain the hope that this short article will help towards a clearer understanding of the ideas expressed.

II.

INFLUENCE OF NATURAL CONDITIONS IN NEW ZEALAND ON THE NATIONAL CHARACTER*

THE subject selected by the Debating Society for the essay of the season is one that has not been much discussed, and which possesses in a very considerable degree the freshness of novelty. What effect have the natural conditions in New Zealand on the national character? It is at once manifest that we are here confronted with a very comprehensive, as well as a very interesting question. The moulding influences of our national character—the character, that is, of the people of the colony—must always be of interest; the matter touches us closely. But the field opened up by the question, as stated, is very wide, and to exhaust it would require the space of many volumes, and a pen guided by a breadth of experience and investigation to which the writer of this essay can lay no claim. If, however, within the scope of the present effort, the subject cannot be treated with anything approaching exhaustiveness, a few remarks on its more prominent phases may afford some food for reflection.

In view of the teachings of modern biology, it can scarcely be questioned that environment, in the shape of climate, proportion of land area to the population, and generally, the physical characteristics of a country, all make themselves felt, to some extent, in the temperament of its people. We are told that some animals, such as rabbits, tend to assume the colour of the country they occupy; and it may be inferred that man, with all his greater sensitiveness, will, in a measure, reflect the sunshine, the storm, and the various aspects and conditions of Nature with which he is brought in contact. In New Zealand, as in every country, more or less, Nature is doubtless presented in some distinctive forms. Can we trace, then, as a result of these, any characteristics commencing to impress themselves on us, as a

*** Prize essay, *Otago University Review,* 1899. See Author's Note No. 1, page 185.**

people, and tending to distinguish us from our cousins in the Mother Country? Are such effects likely to be accentuated by time, or will they disappear as the colony grows older? These are the questions which present themselves for consideration.

The aboriginal natives, it may at first be thought, will exhibit the result of the country's influence on its inhabitants; but the short time which has elapsed since the Maoris first set foot in New Zealand makes any deductions from this source exceedingly hazardous. They were originally a tropical people, their ancestors having probably come from the Malay Peninsula, where their racial characteristics must have been moulded through ages. The heriditary element is consequently the predominant one, and it must not be concluded that, because the Maoris manifest an imaginative mind, or a lazy disposition, these peculiarities have resulted from the impress of their present surroundings. It is true that the imaginative and poetical proclivity may be plausibly attributed to the magnificent scenery of these islands: the winding river, the forest-clad hills, and the glistening mountain peak, each irresistibly suggesting some spiritual counterpart. But the ultimate effect on the mind of these natural phenomena must always be conditioned by the susceptibility of the subject to the poetic suggestion, which is always discernible, even in the most commonplace surroundings, by the seeing eye and the hearing ear. Though there is probably no tract of country in the world more richly endowed with the elements of the sublime than the rugged and far-extending Rocky Mountains of America, we do not hear that the Indians from these parts are anything but dull and phlegmatic. Further, as the matter is more closely approached, the rational *a priori* deduction would seem to be that a people continually face to face with the strongest possible stimulants of any sentiment should tend to become indifferent to their influence. To one who habitually sees Nature in its more prosaic aspect, an occasional glimpse of more entrancing scenes liberates, with overwhelming force, the sense of beauty or grandeur, the susceptibilities for which have been accustomed to respond to much less powerful appeals. But with scenery, as with almost all things,

familiarity breeds, if not contempt, at least a considerable amount of insensibility.

The poetical element in the mind of the Maori, then, cannot be attributed to a close intercourse with scenic display, which, if the foregoing conclusions be just, would tend to act in quite an opposite direction. The case of the white invaders of the country may be regarded in the same light, in so far as the exigencies of population permit them to have free contact with Nature. The rugged hill may lend itself admirably to metaphor, but, in the mind of the shepherd, it is too closely linked with footsore wanderings after straggling sheep to be strongly suggestive of any finer analogy. The conditions will not be favourable to the fullest development of the poetic instincts as applied to Nature as long as the subject matter is too common to be impressive.* This is illustrated by the tone of what may distinctively be called colonial literature, including poetry such as that, to take a typical example near home, of Mr. D. McKee Wright. There must be, in Nature, a certain " aloofness " from the ordinary affairs of life, in order that its poetic aspects may impress themselves with full effect. To the mind engrossed in abstract business, and worried with petty wrangles, or tired with the ceaseless ebb and flow of human institutions, the wide-reaching moorland and the placid lake entwining the base of the everlasting hills stand out in their serenity and immovable grandeur as imposing types of the immutable and ability reality. But when these same phenomena are bound up with prosaic life and the struggle for existence, they lose a great part of that charm; and the poetry which they inspire has reference more to the emotional phases of man, as he copes with, and endeavours to overcome, their refractory obstacles, than with the symbolism of the phenomena themselves. In poetry such as that of Mr. Wright, the river or creek, unlike Tennyson's Brook, which is made a type of the everlasting in contrast with fleeting human life, becomes merely a man-trap to be dreaded—a danger torrent, whose swollen and gurgling waters may perhaps engulf an unsuspecting or muddled rabbiter as he makes his way homeward in the dark to an outlying and

* See Author's Note 1, page 185.

NOTE.—In the thirteenth line from the foot, read "**abiding**" *instead of* "**ability**".

lonely hut. The cloud-capped mountain peak, which, with Byron, figures the chilly darkness that heads the ascent of fame, here is set forth as extracting groans from the lost and hungry swagger, as he wearily travels up rock and down precipice, endeavouring to make his way to the low-lying lands beyond. The conclusion is that the general attitude towards Nature in New Zealand, as in all new countries where men are engaged in doing battle with her, is not poetical, and that, where poetry does emerge, it will be chiefly introspective, will deal more directly with the soul of man than with the soul of Nature.

It has been stated, in reference to the Maoris, that their characteristics must be principally due to hereditary propensities. The same assertion applies to the colonists. We are still Britons; and many centuries, at least, must elapse before ancestral predisposition gives place to environment as the paramount influence determining national character. This would be so even were the change of circumstances severe. From Great Britain to New Zealand the change is not at all severe, especially in climate, which is calculated to affect most strongly racial disposition; and the great characteristics of the Anglo-Saxons will always be exhibited by the people of this colony. The climate of the northern provinces certainly approaches the tropical, and these parts may consequently have a slightly enervating tendency; but, if we take New Zealand as a whole, the just conclusion appears to be that the climate does not sufficiently differ from that of the Mother Country to affect, in any considerable degree, the bodily or mental constitution of the colonists or their descendants. It is not, therefore, to the climate we must look for a clue to our present enquiry: no important result can be attributed to its agency. A more fertile field is to be found in the pristine state of the land, the sparseness of the population, and the consequent predominance of rural occupation. New Zealand is essentially a rural country. No doubt some manufacturing is done, but this is principally for home supply. Of the exports from the colony, gold is the only considerable item other than agricultural and pastoral products, and gold mining may also be regarded as a rural pursuit. There are as yet no large

cities, and the business of the towns we have is in such close touch with the country that the latter may be put down as exercising a governing influence. What may be termed the city mind is doubtless found, to some extent, in the large towns. There are clerks engaged in office work who are constantly figuring out accounts connected with country matters of the nature of which they neither know, nor care to know, anything. But any such estrangement from Nature which exists here must be trivial in comparison with the state of affairs in the large cities of the Old Country, where millions of men are employed writing about things which they have never seen and never can see, or toiling at the manufacture of castings or other pieces of machines, utterly ignorant, not only of the ultimate use of the complete mechanism, but also of the place in it which the article is to occupy. It has been said that, in the manufacturing towns of England, hundreds of men are engaged in the manufacture of fencing wire, which, for all they know to the contrary, might be intended for fishing lines. Here, then, is a vast difference between our colony and older countries in respect to the general relation of the people to Nature. In New Zealand every apprentice in an implement factory at least knows that a plough is used for turning over the ground; there are no armies of men in commercial establishments who have a mechanical understanding of business forms, while they know nothing of its matter; and to the student at the Universities there is not the same danger of the charge which Goethe lays at the door of Faust:

> From living Nature thou hast fled
> To dwell 'mong fragments of the dead;
> And for the lovely scenes which heaven
> Hath made man for, to man has given:
> Hast chosen to pore o'er mouldering bones
> Of brute and human skeletons.

When it is considered that the whole tone of the colony is rural, and that the great majority of the people are face to face with Nature, it will be seen that those characteristics which distinguish the mental and physical constitution of a country population from that of the closely crowded inhabitants of cities will be found predominant in New Zealand. The first inference from this, in respect to intellectual

quality, is that the intelligence will be broad and practical, as opposed to the abstract and formal. Although it has been customary to connect bright intellectuality with the city and dullness with the country, a closer investigation will show that the mental difference is one of kind rather than degree. The average country mind is as fully equipped as that of the city, but it runs in different grooves. A minute insight into details, a clear representation of individual things as they actually exist, a shrewd and well-practised faculty for adapting means to required ends—these are some of the characteristics most fully developed in those who confront Nature at first hand. To use the language of logic, the particular and concrete are more familiar than the general and abstract. This is not to say that the volume of knowledge is small, for it is certainly just the reverse, but that the mind grasps its objects separately and in detail, reasoning more from one particular case to another than striving consciously after generalizations or universal propositions. The latter are more sought after by the aspiring intelligence of towns; but, while covering a greater area of cases, they do not tend to stimulate a ready application of the " minor premise ", without which the practical conclusion cannot be drawn.

In passing judgment on the relative merits or desirableness of the two types of intellect set forth as broadly characterizing, respectively, a rural population and people closely packed together in cities, who are consequently more engaged in theoretical pursuits, it must be remembered that the intellect, besides being primarily a means to an end, may be regarded to some extent as an end in itself. The faculty of generalization and deduction is commonly looked upon by metaphysicians as that which differentiates the mind of man from that of the brutes, and as the highest and best phase of thought. This is just; but perfection does not consist in an undue development of the differentiating element, but in giving the various modes of mind their proper proportions. Viewed as a *means* to practical ends, there can be little doubt that the detailed and particular type of intelligence, here attributed to the country, is the superior. In dealing with Nature, it is the incalculable elements that for

the most part exercise the determining influence, or, at all events, those elements the deductive calculation of whose effects would occupy more time than can ever be spared. The practised waggoner knows better whether or not he can drive over a given side slope without capsizing, by intuitively comparing it with similar places which he has previously encountered, than he could ever judge from any knowledge, however clear, that equilibrium depends on the centre of gravity falling within the base. In driving home a stake, the proper delivery of the blow can be arrived at infinitely better and more expeditiously by trying a few different positions than by making any computations from the rule that the energy of the stroke varies directly as the product of the mass of the hammer and the square of the velocity. Of course, practical knowledge may be found in conjunction with, although not resulting from, a strongly developed faculty for abstraction and generalization; and this combination is most effective of all. But, generally speaking, the two forms tend to separate. The abstract is opposed to the concrete; reflexion is opposed to observation. In the lower animals the latter faculty is most fully developed, probably because the former is altogether wanting. In consequence we find brutes with unerring memories and most susceptible of lessons from experience. A dog ten months old is better able to cope with Nature within its sphere than a child of as many years; better, in fact, than many an adult man. Of course the lower animals through lack of the power of reflex thought, have their limitations; they have not the rational faculty of man. But man can never combine with his intelligence their alert watchfulness and close observation. The mind which would remain practical, however, cannot eliminate those functions which are so indispensable to success in the struggle for existence. It must learn to accept and appropriate with alacrity the teachings of its environment without unduly pausing to consider if they can be syllogistically explained. It is true that the general includes the particular; but it is also true that the particular typifies the universal, and is, moreover, unshorn of individual peculiarities, which are usually of the greatest importance, but which it is the very nature of

generalization to suppress. The term intellectual is, as a rule, applied to that class of mind which spreads itself, even though it be but superficially, over a large area of knowledge. In populated centres mental power, where it exists, develops more readily in this direction on account of the facilities for obtaining second-hand information from all quarters. But such a mind *tends* to exclude details; and, where it does so, it represents only one department of the cognitive sphere of man. On the other hand, where intercourse with the primary sources of production is closer, and where the momentous desideratum is a mental equipment best adapted to cope with Nature, a form of intelligence emerges which, although probably containing a greater number of items of knowledge, is less widespread in its scope. Unhealthy extremes are possible in both the directions indicated. A man may struggle up the slopes of theory till actuality is left altogether behind, the heated mental faculties fuming off in empty vapourings; or he may so confine himself to his particular sphere that his rational prerogative becomes chilled and paralysed. In New Zealand, if danger exist, it will be in the latter direction—colonials are not inclined to dwell overmuch on abstractions. This is perhaps well, for, after all, the best-balanced minds are not those that run riot in theory. Men may build stately temples, dedicated to reason, whose sparkling domes and pinnacles and inspiring marble halls may delight the souls of the architects; but more humble structures are often of greater utility. The phase of intelligence which grasps things as they appear in their diverse aspects rather than in their ideal relations can, from its inherent usefulness and healthiness, never be lacking in dignity.

From the consideration that our surroundings in New Zealand are conducive to a trend of intellect adhering more closely to the concrete than to the abstract, some associated inferences may be drawn regarding the relative development of the higher emotions and sentiments. It must be confessed that a restlessly active life, such as has been assumed to form the outlet for a great part of the physical and mental energies of the colony, does not tend to promote refinement of taste and feeling. This confession may be

made without being interpreted as in any high degree uncomplimentary. As fingers that are accustomed to laborious and honest toil soon become hard and less delicately discriminative in the touch, so the mind whose business it is to confront the stern and pressing problems connected with production tends to lose some of its sensibility. In our towns there are doubtless many persons engaged in mere routine or theoretic business to whom this condition does not apply; and this class will represent more strongly what may be called, in the wider sense of the term, sentimentality. But the population as a whole is not so engaged. In fact, as has been previously suggested, the relation in this respect between the country and the town within our own shores may be taken as illustrating that which exists between the colony generally and more thickly populated lands. In towns employment is so diverse that conversation can find no effective vent in practical topics. Abstractions are consequently more reverted to as being impartial in their application and of common interest. With abstract thought the ideal sentiments are more closely associated. On entering a city, even one of Dunedin's magnitude, a man from the country, where the utilitarian aspect of things is paramount, experiences a peculiar feeling after he has overcome the effects of the business bustle. The sky-pointing spires and monuments, the motionless and meditative statues speaking of the dead past, the mystic university and museum, the display of beautifully imaginative pictures in galleries or artists' windows, all tend to raise the mind, so to speak, into a dreamy realm, heavy with the vapours of the human spirit. Archbishop Whately, in his work on rhetoric, deals very strikingly with the effect of numbers in swelling the emotional susceptibilities of an audience. Often that which can send a thrill of fervour through a vast concourse of people would, if addressed to one or a small number, appear as mere hyperbolical rant. The strength of personality behind each utterance is augmented by every person present, for every one is conscious that the whole gathering is moved similarly to himself. There is thus an echoing and re-echoing of feeling, a kind of mental resonance, which intensifies the effect. Something analogous to this takes place in a crowded

population. Thoughts and emotions come thicker and more strongly through our contact with others. We observe their feelings, and we are conscious that ours are in a measure reflected by those about us. Thus emotions tend to swell and become prolonged, whereas when people are separate, an incipient feeling is readily dissipated and absorbed by the more vacant surroundings. In compact populations, then, where emotionalism in this manner becomes more pronounced, things connected with sentiment will find fuller expression. The subtle suggestions of fine art will be more readily appreciated, and a general refinement of æsthetic taste will be observable. In religious services there will be a demand for the symbolism of ritual, and in many other ways the idealistic mind will manifest itself much more strongly than in thinly peopled parts. There is a danger, however, connected with strong development of the sentiments to which country populations are not so subject. Morbidness is more readily developed. Full occupation with external things leaves the mind fresher than constant reversion to matters with a subjective reference. The latter are more exhausting to the faculties, and may eventually tend to induce dullness, ennui, or distorted views of life. We may congratulate ourselves that from this evil the conditions in New Zealand tend to divert us.

An element which has not yet been touched upon, and which must exercise a considerable effect on the mind of New Zealanders, is the pristine state of the country. We have a free hand to develop it in any direction that may seem most desirable. There are no institutions of the past which, by their irresistible inertia, force themselves upon us. There is a clean sheet to work upon, and all the faculties must be summoned to fill it up in the most advantageous manner. In older countries there are grooves of activity which have been worn deep by time, and which can be got out of only by laborious degrees. They appear to be so firmly set that the majority of people have not the courage to attempt to break through them, or even to consider the possibility of such a thing. Here the case is quite the reverse. When the colonists first arrived, there being no existing systems, everything introduced was new, or, at all events, new to the place.

Of course, institutions would at first tend to take the form of those in vogue in the Mother Country; but, at the establishment of these, the colonist, who had experienced a revelation of his own power, would not stop. Having seen how Nature and circumstances would yield to the strength of his right arm, he would naturally push boldly forward and confidently introduce novelties which might appear good to him, regardless, in great measure, of precedent and custom. These primitive conditions, although now things are somewhat more firmly set, obtain materially to-day, and the same view of matters is still very prevalent. The people in all countries newly opened up and in course of being reclaimed from Nature will present similar characteristics in this respect. Some remarks of Mr. C. A. Green, representative to New Zealand of the proposed Commercial Museum at Philadelphia, may be quoted here. The extract is taken from a report of an interview with Mr. Green published in the *Otago Witness,* and it may be assumed from the position of this gentleman that he has had a wide commercial experience, and possesses a knowledge of the peculiarities of different countries. He says: "One thing that has delighted me very much, and made me feel very much at home out here, is that the Australians—and in speaking of Australia I don't make any distinction between Australia and New Zealand—the Australians are very much like Americans. There is a sort of 'goaheadiveness' about them—a sort of restless activity, that is so much like our people. You don't stop at any difficulties, but go ahead; and you have not got those extreme conservative ideas such as you find in the Old Country." Mr. Green here places America and Australia side by side, as tending to Radicalism in commerce and politics. This is undoubtedly due to the lack of restraint from established institutions with the weight of ages behind them. There are many things to be gained by this energetic proclivity, but there is also a danger of overstepping the limits of prudence. When it is discovered that some of the old-established methods can be profitably superseded, too little consideration is apt to be given to the possibility that others of them may be rooted deeply in proven necessity: of all the systems that have

emerged during the centuries, they may have shown themselves the fittest to survive. The safest policy is always to proceed cautiously with innovations. Whether or not legislation in New Zealand has passed beyond the boundaries of safety need not be discussed here. The fact to be observed is that a Radical tendency exists in our politics, and that it may be traced to a spirit of bold assurance in the people, resulting from a so-far successful subordination of Nature, and a consequent impetus to proceed further and mould all refractory surroundings to the shape that seems most inviting.

It may be thought by some that the prevalence of Radicalism in our politics contradicts what has been said concerning the *practical* nature of the colonial intelligence. Is not Radicalism closely connected with idealistic and theoretic notions? The answer is that the advance of this cause in New Zealand is attributable more to opportunity than to theory. Vested interests and unquestioned traditions do not here offer such serious obstacles to the progress of so-called " Liberalism " as they do in older countries. The consequence is that the " Havenots " see, or think they see, the chance of improvement. Theory is a very secondary power in politics. In forming opinions men do not, as a rule, collocate ideal doctrines of right and justice and then impartially deduce conclusions. By the method most commonly adopted the individual ascertains what will promote his own interest, or what flatterers persuade him will do so, and then allows ideals to fall into line—forms desirable conclusions first, and subsequently casts about for suitable premises. Nor is it necessary, in proceeding thus, to be conscious of the sophistry. The intention may be perfectly honest. If we consider that philosophers, whose profession it is to sift the matter thoroughly from a disinterested point of view, have in all ages been able to support diverse and contradictory doctrines concerning even the fundamental moral ideal, the *summum bonum* of existence, it is not surprising that common people can easily find plausible and satisfactory ethical foundation for almost any political creed. It would be a mistake to connect activity in our political arena with any enlarged aspirations on the part of

New Zealanders after abstract equity. The phenomenon is due to the very different cause to which allusion has already been made.

An allegation, which has been so often repeated that it must be assumed to have some basis in fact, may now be briefly adverted to. It is said that colonials are lacking in reverence. This is doubtless a thing to be deplored. Not to venerate those things that are really venerable is a grievous fault. Yet we cannot well escape the overwhelming testimony that this defect is noticeable in New Zealand. Moreover, it may be connected without much difficulty with the operation of the natural conditions. It is a result due to causes whose consequences have been traced in our politics. There are no ancient human institutions, buildings, monuments, or ruins, hoary with age and linked with venerable associations, to stir the imagination and induce the reverential sentiment. There is no legacy from ancestors. Colonials can stand up, swelling their chests with serene satisfaction and complacency, and, pointing to their country with all its flourishing institutions, exclaim "Alone we did it!" This self-gratulation is very good within reasonable bounds; but, without doubt, it is essentially opposed to the spirit of reverence. In the Old Country there is perhaps too much cringing and grovelling before position, and we are well rid of anything of that sort. But there is an evil at the other extreme. Self-respect is capable of exaggeration, and the old proverb which places pride as a prelude to destruction might, in many cases, be profitably reflected upon. If there is a lack of reverence in New Zealanders, the circumstance must affect the character and intensity of the religious feeling. Reverence is a fundamental element of religion. This, however, opens up a field too wide to be entered upon here. But it may be remarked that the same agencies which have induced Radicalism in politics are probably operating to some extent, and in a similar direction, on the religion of the people.

Most of the observations which have as yet been made have dealt with the direct impress of the surroundings in New Zealand on the mind. The effects on the physical constitution will also be reflected in the character of colonials.

There can be little doubt that the environment in this country is conducive to bodily vigour and health. We have no large manufacturing cities where vast numbers of men work in smoky and insanitary confinement. The abundance of fresh air, the active nature of the predominating vocations, and many other favourable influences will tend to freshen the glow of the vital spark, and stimulate energy and enterprise.

Some of the more striking effects of the natural conditions in this colony on the national character having now been indicated and enlarged upon as fully as proper limits will allow, it only remains to be noted that, as time advances, our relation with Nature will alter. The population will increase, cities will spring up and most of the present distinguishing circumstances, whose influences have been here investigated, will disappear. Consequently the traits of character which these conditions are to-day tending to induce will then become less marked. There is no strong reason to suppose that the characteristics which we have inherited from our ancestors will be permanently disturbed, in any great degree, by the new surroundings, or will show much ultimate alteration after the flush of the colony's youth is past. An evolution is, of course, always taking place independent of change of environment, and it may be that the rejuvenating and invigorating power of a new and healthy country will accelerate that process. When, after a round of exploration, prompted by an exuberance of youthful spirits, we again approach the old track, it may be found that the course has not been altogether circular, but has culminated in a spiral ascent. Then the New Zealander, with the ground firm beneath his feet, should be able to lead his country in the very van of progress; and he will doubtless do so if, undaunted by difficulties or obstacles, he presses still forward with courageous energy, and, like Longfellow's Alpine climber, clasps with unrelaxing fingers and waves ever above and before the symbol of advance:

"The banner with the strange device,—
Excelsior."

III.

THE MOVEMENTS OF THE HEAVENLY BODIES AS A MEASURE OF TIME*

According to Lord Kelvin, measurement is the beginning and foundation of Science. The three fundamental units in physical science are the units of length, mass and time. Of these three things time is probably the most elemental.

In considering the question of time measurement it may be useful to make some comparisons with measurement of space. The first standard of length was probably connected with the human body and its parts, as evidenced by such terms as "hand-breadth", "foot", etc. And if the whole outward world of material phenomena were in continual flux and uncertainty it is probable that the human body would remain the real and essential gauge. As it happens, something more stable can be found, although it is difficult, if not impossible, to get anything absolutely stable. The quest is for something objective, which will remain most constant relatively to other things; for example, a platinum bar at a given temperature. If, then, such a bar be put aside as a standard, it is the absolute guide for all measurements. There is no appeal: To say, for example, that the standard bar and all other things in the Universe are really increasing or diminishing in size altogether, can scarcely be either true or untrue. It is really meaningless. I say this to show that measurement of space is merely a matter of comparison—so with Time.

As the ultimate reference for spatial measurements might be the human body, so the ultimate reference for time measurements would be the human mind. But, as the body varies in different individuals (and even in the same individual at different times) so in like manner the length of time required for a given sequence of ideas varies both in the same person under different conditions, and also in different individuals. If a man's mind were so rapid of action

* Paper read to Astronomical Branch of Otago Institute, 1916. See Author's Note No. 2, page 185.

that he could appreciate and feel in what we call a minute, everything that the average man could cram into an hour, a minute in the case of the first would be virtually equal to an hour in the second case. It will therefore be seen that something external for general reference is essential in a satisfactory standard. Now it is noted that there is a certain agreement in the period of sequence of events. For example, a pendulum of a certain length will swing so many times while a stone is falling from a tower, and the number of times is found to be approximately the same on all occasions. Again, during the time occupied by a certain number of oscillations of a pendulum, as measured by a clock, an animal or vegetable will grow to maturity, or a certain number of tides will ebb and flow. And it must be noted that these intervals correspond fairly constantly to the intervals required for given mental processes. That is to say, that a normal man could perform a similar amount of mental work in the period of, say, a thousand pendulum oscillations whenever the test might be made. If a standard did not conform to the latter condition it would certainly not be acceptable as a measure of time. By noticing all these agreements we come to conceive the idea of time as something definite and objective, and we look for some exact standard.

It is obviously impossible to do as is done for a length unit, namely, to put away, say, a bar of platinum for reference.

The regular sequence of night and day would perhaps be the most arresting fact to be taken first, historically, as a measure of the flow of time, and no doubt that was taken. Then observers gradually came to recognise the causes of night and day in the heavenly bodies. Finally, direct observation of these bodies, conjoined with mathematical principles, led to our present accuracy in determining points of time.

It would be interesting to speculate what our standard of time would be if—as is perfectly conceivable—our planet were alone in space. In that case there would not be sun, star, or moon visible in the sky, and it would be necessary to have recourse to a terrestrial standard. Rough and ready

methods might be employed—the time, for example, of the burning away of a candle, or the falling of a certain quantity of sand through an aperture. A better standard could no doubt be obtained from the swing of a pendulum as recorded by a clock. That is really dependent on the same marvellously uniform force which operates so regularly on the heavenly bodies. But a pendulum is subject to disturbing influences; for example, the resistance of the medium through which it oscillates, and the friction on the pivot.

These factors can doubtless be minimised by proper precautions, and clocks are in fact made which keep time with wonderful accuracy. But it would be quite impossible to guard a pendulum absolutely from disturbing influences. An earthquate, for one thing, might vitiate its accuracy. The very best timekeepers must be checked occasionally. So it will be seen that there would be nothing available subject merely to the single force of gravity.

Let us consider, then, the apparent motions of the sun and stars. I say the apparent motions, for we know that in reality the Earth rotates on its own axis, and that it revolves round the sun. It is nevertheless convenient and permissible mathematically to regard the earth as the fixed centre of reference. It is also approximately, though not absolutely, correct to say that the line of the earth's axis always intersects the celestial sphere at the same two points—north and south. By the celestial sphere is meant the sphere described with the earth as centre and a fixed star as radius. The annual movement of the earth round the sun is so small in comparison with the distance of the stars that the change of position, vast as it seems, is negligible in relation to the star sphere, except for the most refined observations. There are slight displacements of the line of the earth's axis owing to the phenomena of precession and nutation, in virtue of which and from other causes, circumpolar and other stars vary slightly in right ascension. But these phenomena are understood and can be allowed for. In any case, for a properly selected star they would cause a very slight error in an observation.

Leaving these minute complicating factors aside for the present, consider the earth, the sun and an equatorial star. Imagine an observer on the earth at some point not too near either pole. Imagine also that to mark the meridian of the place he has a vertical wall set in a true north and south line. The star will appear to revolve round the earth from east to west each day, and at a certain time, namely when it is crossing the meridian of the place it will be aligned with the plane of the wall. Now the period elapsing between the star's passage of the meridian one day, and its passage of the meridian the next day, is known as a sidereal day or star day. It is really a measure of the time taken by the earth to revolve on its axis. This is our fundamental unit of time, and it represents 23 hours 56 minutes 4.1 seconds of our ordinary or mean solar time. Clocks may be, and are, made to measure sidereal time. They are called sidereal clocks, and register units which are rather shorter than our mean solar units: Why, then, do we not use sidereal time in common life? The reason is that our day period must conform approximately to the natural succession of light and darkness. The sidereal day only differs by a few minutes from the natural day and night cycle, but it is obvious that after a time this difference, being cumulative, would cause a wide divergence, and we would have twelve o'clock occurring sometimes in the morning, sometimes in the evening, and again sometimes at midnight. The movements of the sun must be considered, and that brings us to SOLAR time.

The apparent daily course of the sun is by no means so constant as that of a star. It is, in fact, rather erratic. Our observer at the vertical meridian wall who, let us imagine, has provided himself with a sidereal clock, would find that the interval between the sun's successive visits to the meridian was longer than in the case of the star. He would also notice that the delay varied somewhat from day to day, the amount of variation being quite appreciable on the sidereal clock. Let us now take these facts and seek an explanation. First, the cause of the lateness of the sun at the meridian

post each day. This is due to the apparent annual motion of the sun round the earth, as observed against the background of the star sphere. It is a backward movement from west to east, or contrary to the direction of apparent revolution of the stars. As an illustration, imagine an observer stationed at the centre of a merry-go-round, with his eye fixed in one definite direction. He would observe each rider passing his line of vision at successive equal intervals. But if an acrobat on one of the ropes started climbing backwards, it is obvious that he would take longer to make the revolution in front of the observer. The normal riders represent the stars, and the acrobat the sun. This backward movement of the sun is completed once in a year, and in consequence he seems to take only 365 daily revolutions in the year instead of 366 in the case of a star. If that retardation were evenly distributed over the days of the year he would be 3 minutes 55.9 seconds late each day at the meridian post. In point of fact, at some periods of the year the daily retardation is greater than this, and at other periods it is less. The acrobat in the illustration is a little erratic in his backward climb. In the case of the sun this circumstance is due to the fact that the ecliptic or path of the sun is not on the equatorial plane. In other words he is not always moving backwards against the star sphere. At the solstices he is doing so, but at the equinoxes a considerable proportion of the motion is in the north and south line. Consequently, in the latter case the direct backward component (or the movement in right ascension) is diminished. Another reason is that the orbit of the earth is not circular but elliptic, which again causes the apparent motion of the sun against the star sphere to vary according to the time of year.

As a result of these irregularities the solar day, or period between two successive passages of the sun over the upper meridian of any place on the earth's surface, is inconvenient for a standard. In order to overcome this difficulty, astronomers have devised a system of time based upon the average or mean period of the daily meridian passage of the sun. An imaginary sun (called the *mean* sun) is conceived to

make its daily revolution round the earth in the equatorial plane in one year cycle. The mean sun maintains the same average speed in this plane as the real sun, and the two suns are actually coincident four times in each year, having furthermore made exactly the same number of revolutions as the real sun. The mean sun will show a daily retardation of 3 minutes 55.9 seconds against the stars; this amount being, of course, the average retardation previously alluded to. The period between its upper meridian passages is rather less than 24 hours 4 minutes of sidereal time, and is known as the SOLAR DAY. This mean solar day is the basis of our ordinary time, and as is well known, it is divided into 24 hours, each hour in turn being divided into 60 minutes, and each minute into 60 seconds. By this system a unit of time is devised which is practically coincident with the natural day period. Mean noon occurs at the instant of the passage of the mean sun over the upper meridian of the place in question, and the astronomical day starts from that point. The civil day is, however, reckoned to start from midnight.

Before going into the question of the standard time of different countries, let us briefly consider the practical methods of determining time by observation of the heavenly bodies. It will be noticed that, while an imaginary mean sun is a useful thing to postulate, it is not an object capable of being observed by instruments or otherwise. How are we to know when it is on the meridian? Well, we must observe the real sun and make allowance for the calculated difference between its position and that of the mean sun. This difference is known as the Equation of Time, and it is constantly varying. The equation of time can be predicted with great accuracy, and its value for every day is recorded in the Nautical Almanac. At some periods of the year it is a positive quantity; that is, it must be added to the apparent time; at other periods it is negative, and must be subtracted. In the former case the mean sun is leading in the heavens; in the latter case it is following the real sun. I should remark that when the real sun is on the upper

meridian the time is called APPARENT NOON; and similarly, the time which corresponds to the position of the sun in its daily revolution is known as apparent time.

A few words must now be said about the method of determining when the real sun is exactly on the meridian. The observer looking up the vertical wall set north and south would get a rough idea of it. The precise instant can be found with great accuracy by means of a transit telescope. By a transit telescope is meant a telescope set upon trunions, which permit it to rotate in the plane of the meridian only. That is, the axis of the instrument will always be aligned either with the zenith or with a line joining the zenith and the celestial poles. There must be cross wires in the telescope to mark the optical axis with precision. To take an observation the telescope is directed to the point on the meridian which the sun is approaching. The sun will gradually come into the field of view, and at the instant of contact of the edge of the sun's disc with the vertical wire the time is noted by a reliable watch. To obtain apparent noon directly, it would be necessary to observe the centre of the sun, not the edge. That, however, could not be done so accurately, because the centre is not a definite visible point.

An allowance is therefore made for the length of time occupied by the passage of the semi-diameter over the meridian. This allowance can be found ready calculated in the Nautical Almanac for each day. When that short interval has elapsed we arrive at apparent noon. The next step is to look up the Equation of Time for the date and hour of the observation, and this will be added or subtracted according to the direction in the Almanac, which depends on the period of the year. The result will be true mean time.

It will be seen that the allowances just mentioned might be computed, and a stop-watch set to the calculated mean time of the passage of the leading edge of the sun over the meridian. If the watch were then started smartly at the contact, it would record the correct mean solar time of the spot on which the telescope was set. A large transit instrument is usually installed at the important observatories, and

kept scrupulously correct. Thus the correct time can be obtained for the benefit of mariners and others. Mean time can also be obtained from observation of the meridian passage of the moon or stars. In these cases the proper computation must be made for the difference in right ascension between the observed body and the mean sun at the instant of observation. The Nautical Almanac again supplies the data necessary for making this computation.

I must now note another point which will probably have been anticipated by my hearers. The mean time is the same along any one meridian of longitude on the earth's surface, but is different for each meridian. Even in a small country like New Zealand there is a wide difference in the mean time in different localities. The difference amounts to four minutes per degree of longitude. In the case of New Zealand it amounts to about 48 minutes between the extremities of east and west. Now it would obviously be quite impossible to have a different clock time for each place. Most countries have therefore adopted the principle of STANDARD TIME. In New Zealand one standard covers the whole of the Dominion. In selecting a standard meridian care is taken that it divides the area fairly centrally, and the mean time of that meridian is used for the whole area. The standard meridian of New Zealand is 170° 30′ east of Greenwich. In time measurement this is equal to 11 hours 30 minutes in advance of Greenwich. The meridian of Greenwich is, of course, the one from which all Nautical Almanac data are calculated.

In continental countries it is necessary to divide the territory into zones, and allocate a standard meridian for each zone. In Australia, for example, if a standard time were taken for the whole continent, the divergence from the true local mean time would be too great at the extremities. So in Australia there are three zones of time. In the United States of America there are five. It is a little inconvenient for people living along the divisional line. They have two sets of time to consider; but the divisions are usually arranged to cause as little inconvenience as possible.

A good deal of confusion exists in some minds in regard to the terms "sidereal time", "mean time" and "standard time". I trust I have made it clear that no special mathematical knowledge is necessary to distinguish them.

I do not wish it to be understood that the method of meridian observation is the only one for determining the time astronomically. If the latitude of the observer is known, the time can be computed from an observation of the altitude of the sun or other heavenly body. This is not a difficult task, but I cannot here describe the method in detail. Suffice it to say that the angle between the observed body and the local meridian as subtended at the celestial pole, is an exact measure of the progress which the body in question has made in its daily apparent revolution. Hence the local mean time can be deduced; and also the standard time, by adding or subtracting the difference between the local and the standard meridians. In this observation for altitude allowance must be made for refraction of light on its entrance to the atmosphere, and also for parallax. The allowance for parallax is necessary to compensate for the distance and angle of the observer from the centre of the earth. This last method is very convenient for surveyors and others in the field. It can be used with the sun at any position not too near the horizon or the meridian. The meridian method suffers from the disadvantage that the sun may be clouded just at the instant of its passage, and the day may thus be wasted. An altitude can be taken by a theodolite or a sextant. In the latter case an artificial horizon is necessary when the sea is not visible.

A few words in conclusion on Time Signals:—In some places, notably seaports, a gun is fired at a certain hour every day, or a time-ball is dropped. Chronometers can thus be accurately checked and watches set.

It has often struck me that Dunedin is rather backward in this matter. It is exceedingly difficult for a stranger—and even for a local inhabitant—to obtain the exact time here. Perhaps it would be a good move on the part of this branch of the Otago Institute to promote a scheme for a

standard clock. A signal is given occasionally by direct wire from Wellington to the local telegraph office. The office is obliging in the matter, and will notify anyone desiring it when the signal is expected, so that he may attend and set a watch. However, it is all very much in the dark, and very few know about the proceedings at all. In the City of Edinburgh (of which Dunedin is supposed to be a counterpart) there is a public clock placed in the centre of the city which is kept absolutely correct to a fraction of a second by electrical connection with Edinburgh Observatory. I was much interested when on a visit there to note how much this clock was used. At almost any hour of the day some people would be there in the act of making an exact check on their watches. I suppose we cannot hope as yet for a very expensive outfit. But a good clock carefully checked to the second every day is a thing which a public-spirited community might easily enough provide for its own convenience. It would be very useful to amateur astronomers, and it would doubtless help to instill the virtue of exactness and punctuality into the community.

I suggest that (if not now, at least after the war) this matter might well be taken up by our branch.

NOTE.—Since the date of this essay the following changes have occurred:—

N.Z. Standard Time has been altered to 12 hours in advance of Greenwich, the Astronomical Day is now reckoned as commencing at midnight, and radio has revolutionized time signals.

IV.

LAW IN NATURE*

THE phrase " law of Nature " is probably used occasionally by almost everybody. Yet it may be doubted if many of those using the expression, including scientific men, have probed very deeply into its meaning, or have taken the trouble to use it with a uniform connotation. Of course it is quite possible to employ a general idea most usefully, within limits, without extreme precision as regards definition. In fact one might make bold to say that if nobody spoke about things they did not fully understand we should live in a strangely silent world. Nevertheless, lack of precision in the use of terms is probably the most fruitful cause of misunderstanding and controversy when principles come to be distilled out of common methods.

The term " law " is most frequently used, perhaps, in the sense of state law, involving sovereign and subject, and by analogy this use may be extended to any case where there is simply an edict of authority. Laws of this kind, be it noted, may or may not be obeyed. They are none the less laws by reason of their being frequently ignored. A perfectly sound and valid law may require all pedestrians to keep to the left, while a large proportion of citizens continue to butt at and confront each other. The law however stands, and I suppose no law of this order is ever universally followed. The point is that, given proper authority of enactment, with reasonable attempts at enforcement, the validity of edict law is not conditioned by the generality or otherwise of its observation.

This being noted, it will clearly appear that another kind of law exists, the validity of which is *entirely* so conditioned. The laws of Nature, which imply no sovereign (at least from the point of view of physical science—I leave out the theological aspect), may be imagined to belong to this class. We could scarcely, one would say, have a law of chemical affinity, for example, which is not universally, or

* Read to Otago Institute, 1923. See Author's Note No. 3, page 185.

at least generally, observed by material substances in the prescribed conditions. This view may require some comment later but, at all events, we here note a second use of the term law—in the sense of what may be called *experiential* law. The word "empirical" might be used, but that expression, in scientific phraseology, is reserved for a special kind of experiential law, namely one which has no rationale to support it. Perhaps the discussion to follow may suggest that the distinction is not a very deep-seated one, although it serves a purpose.

What may be deemed a third kind of law is a combination of edict and experiential law. A law of grammatical expression, for example, derives its sanction largely from usage, but in no small measure also from the edict of a cult of grammarians, who are recognized authorities, and who certainly do exercise some legislative power over ordinary mortals. Such laws, we all know, may or may not be obeyed. The word "rule" may be, and is, used in a loose manner as a synonym for "law". It bears a somewhat less rigid significance, but a rule may be in the nature either of edict law—as when the RULES of a game are laid down, or of experiential law—as when we say that a storm follows a low barometer as a RULE.

So much of a preliminary nature in regard to law; and it will be readily seen that in ringing the changes on the various usages of the word much futile argument might be generated.

Now, what about the word Nature? Is there any room for ambiguity here? ROOM AND TO SPARE! But I think that a first approximation to its meaning can be given. Let us say that Nature is the totality of objects which occupy that single space system which we observe as a common domain. This definition is, like any other, open to criticism, for I believe no definite agreement as to the significance of the term exists. It will serve however as a jumping-off point. I shall refer to some of the anomalies later, but I should say here that the modern tendency is to regard Nature as a whole, while separation of events by time on the one hand, and space on the other, can be looked on as analogous.

My next step must be to indicate the essence of the

method by which laws of Nature are derived. The ancient and mediæval method of arriving at truth was the acceptance of certain intellectual principles as intuitive, and, by logical process, developing these into elaborate consequences. If facts in the world of experience did not tally with these deductions, well, so much the worse for the facts! They were condemned as false appearances. We associate the name of Bacon (Roger and Francis) with the overthrow of this criterion of truth. Learn from experience, they taught in effect, and derive your principles from facts. This process of induction, as it is called, has been the subject of long treatises by modern logicians. The aim has been to provide rules by which, from known facts, safe inferences in regard to the unknown may be made. J. S. Mill formulated an elaborate scheme of rules, but the essence of all is embodied in the principle that if certain occurrences, or groups of occurrences, bear definite relations in a variety of circumstances, they will always bear such relations. When stated thus baldly, and, as I believe, justly, it will be noticed that the principle is by no means of very convincing cogency.* For it must not be erroneously supposed that general principles or laws arrived at by induction from experience are by logical necessity true throughout all Nature. Inductions vary in cogency but the probability of the universality of any law is less than a certainty. Indeed in an infinite universe it would approach zero. That could be shown mathematically; and to consider universal certainty as attaching to inductive laws is either a fallacy or due to the importation of a mystic idea. In the latter case no objection can be taken as long as the matter is regarded as outside of science. Nevertheless by careful procedure and perpetual checking of results marvellous generalization and laws have been arrived at, as the whole body of scientific knowledge testifies.

From the practical standpoint the ascertainment of time relations of phenomena might appear to be most important. If we know what consequents succeed given antecedents we

* It has been usual in describing valid induction to say that no adverse cases must arise, but actually rare discrepancies are commonly tolerated in the hope that the apparent anomaly will be explained.

have a key to the future, and also an instrument of control. Thus are applied the ideas of cause and effect. But the discernment of uniformities in co-existing events—or otherwise in spatial relations—can be carried out by exactly the same principles. Thus the curvature of a ring might be regarded as the cause of its closed figure just as truly as the application of a match is the cause of an explosion of gunpowder. The relations constitute the essence of the thing, and a law of Nature is nothing more than the expression of a generalized relation in Nature. Perhaps I should say that a PERFECT law would be so described, for, seeing that all of Nature has not been, and never can be, explored, the relation is ascertained to hold good over only a limited part of Nature. Nature is then resolved into a system of laws which, when perfected, would describe all its processes.

As I here use the term " law " it must not be taken to mean merely the great far-reaching generalizations—such as the law of gravitation. Some logicians have thus narrowed down its scope. J. S. Mill considers that a law of Nature must be on the grand scale. Probably he would not allow as a law of Nature that a splash follows the dropping of a stone into water. He would resolve that into subsidiary laws. It may be doubted, however, if we have a very definite kind of distinction here. Who can say that any law is not resolvable? Any relation which can be applied generally in Nature is logically a law of Nature. And if we add a term often associated with law—the word " order "—we can say that the scope of law and order in Nature covers all observed relations therein.

Now I propose to offer you some geometrical analogies of this process of discernment of law and order in Nature. Let us imagine a surveyor with a limited knowledge of the task he is about to undertake setting about the survey of a field, He might, as an unskilled beginner, use very unwieldy methods, while a better informed man would supersede them by simpler and more comprehensive ones—just as laws of Nature are gradually evolved often after a laborious journey among unnecessary complexities.

Here is a parallelogram—a four-sided figure with parallel sides and unequal angles. As a first attempt our surveyor might decide to mark off the diagonals, and so isolate the four triangles which together compose the whole area. These triangles could then be measured and computed according to the laws of mensuration, and a perfectly correct solution attained. If the surveyor had many such figures to resolve he might easily acquire the habit of referring to the four sections of his parallelogram by symbols as if they were individual entities. Very well: his successor then comes along and discovers that there may be placed against the parallelogram a rectangle which may easily be shown to equal it in area. He therefore simply multiplies the base by the altitude and has no further need of the elaborate triangle entities, which will therefore be discarded. Again we may have some fragmentary shapes which might cause the first investigator a good deal of thought, and even despair, especially if they should not happen to be presented all at once. The constructive mind will however come to the rescue and fit them together to make a circle—easily dealt with, so that, subsequently, reference to them as separate entities might become unnecessary. As a somewhat different example, a set of points may be given in an apparently promiscuous distribution, and the task set of computing their relative positions. After investigation it may transpire that all points can be absorbed as angular points of right angled triangles* or that two-thirds of them may be coupled in pairs, each pair marking the diameter of a circle, while the remaining third are points in the circumference of the circles. In the first case the right angled triangles, and in the second case the circles, would soon acquire a right to the status of definite entities in the vocabulary of the surveyor who had habitually to deal with such fields of points.

I think it will not require much reflection to see that this process of elaborating constructive entities in sets for convenience affords an analogy to the process of discovering Natural law. In Nature we find a bewildering profusion of facts with which we must deal, not only in the interests of

* See footnote in essay "The Status of Physical Concepts", page 143.

speculation, but in the struggle for daily existence. The necessity for a classification and arrangement which will serve our purposes for economy of thought and action is forced upon us, and instinct sets us at the task from birth onwards. Proficiency here has a very great survival value. Our investigations however may, and often do, stop at a point when we have become sufficiently expert in assessing Nature to avoid accidents, gain sustenance, communicate with our fellows, and prosecute daily life. It may be, however, that our resolution of the elements of experience, although sufficient for these and similar purposes, is very crude indeed. Scientific investigation proceeds to simpler and more general formulae, by which the survey of presented facts moves on towards perfection. In the new syntheses the more primitive ideas may be superseded altogether, just as the fragmentary figures previously suggested give place to the simple circle. Diamonds and charcoal in the common view are very different things but in the atom science unifies them. Perhaps, on a not distant day, all matter, so diversified to appearance, may be resolved into one single basic element.

Thus we find a key to the method of scientific thought. The ancients considered that all Nature could be resolved into four elements (earth, air, fire and water)—a useful combination as far as it goes; but modern science, by its more extensive schedule of elements, has really brought the facts within an easier and fuller grasp. But let us observe more closely how, in applying this method, guided by a principle, which we might designate the principle of easy survey by selective analysis and synthesis, science has proceeded. Then we shall note the value of the results, and some of the by-products of fallacy and misunderstanding.

Now I suggest that all apprehension of Nature whatever, be it even so elementary as the perception of an object, is essentially the recognition of law. A material object exhibits a group of related qualities and it is this relation that constitutes it as an object of perception. Vague, undefined sensations may perhaps be a possibility, but an object, to be apprehended, must be recognized as having some formal content. Milton sings of " In the beginning how the heav'ns

and earth rose out of chaos." Consider the idea chaos. I think it may be regarded as a negative term—the negation of law and order. We may picture chaos as a nebulous mass of primordial stuff tumbling about in the darkness. We may probably describe it as formless, but on the other hand the imagination will be powerless unless we ascribe to it some form. And that is just the weakness of the picture. In so far as we introduce form or qualities we contradict the conception of chaos. All definite concepts must imply some element of law, if even only the law of persistence over a small period of time. Thus law is not an accidental feature of Nature, but of the very essence of it. Without law there could be NO Nature as a field of even the most elementary knowledge. We may define a scientist as a careful, systematic explorer of Nature; but he who discerns an object is a scientist in embryo: he has performed the first basic act in the assessment of his environment. Let him who can imagine a simple object of perception without parts or elements, and I feel sure he will not be able to regard it as an occupant of space. But the perception of objects is only a commencement, and is, indeed, so instinctive that the objects of perception acquire an almost elemental status. The developed mind takes cognisance of an elaborate array of classifications and relations which compose the body of law under which the scientist conceives the whole observable universe to operate.

How comes it (we may now inquire) that Nature (a single system as we are calling it for the present) is diversely considered by so many different sciences? If merely a simplifying survey is required, should not the science of Nature be one, just as its subject matter is one? Why the long list of special sciences—geometry, physics, chemistry, biology, geology, etc., etc. It will be noticed that I have included geometry as a science of Nature. A few years ago this would have been challenged but we have recently been taught that geometry is an empirical study. The multiplicity is due to the fact that pure physical science, which is most nearly of all mathematical, is too slow in its development, and the more complex aspects of things must be dealt with by convenient methods along less rigorous lines. Chemistry

cannot wait for the statement of its laws until all substances, including the organic, have been thoroughly resolved in structure right down to the atom or electron. It has urgent work to do among the complexes, and so it uses terms and concepts such as "metals", "alkalies", "acids", etc., and schemes out laws for interaction of such substances, laws which, if a clear knowledge of the atomic and sub-atomic structure of these bodies were available, might appear as merely special cases of the laws of physics. This applies with greater force to the sciences of life. I should explain here that I speak merely of the physical basis of life, and I leave out of consideration the possibility that there may be laws of life which are quite independent and incommensurate with the laws of physics. So far, and so far only, as the physical bodies associated with life are part of the common space domain, they must participate in the operation of physical laws. If necessary physical laws must be modified to cover anything distinctive in organic manifestations, so that an all-inclusive scheme may be finally obtained. Therefore I say that, on one side of his work, the ultimate aim of the biologist, like that of the chemist, must be to convert the special laws, which are indubitally necessary in the present state of the science, to the general laws of physics, to which of course his researches may make far-reaching contributions. And so on with all the other sciences, which, either in whole or in part, concern what I have called our common space domain.

And what of the science of physics itself? Can it be further generalized? I think it can, and it is fast becoming so. We do not require to look back very far for the time when light, heat, electricity and other things were regarded as mysterious interlopers in the field of space and matter—something different in quality and vaguely conceived as fluids and so on—terms which derive their significance from complex ideas of the mind. I think I am correct in saying that ideas of colour and hardness, which are really psychological, are yet admitted, although the persistent aim is to eliminate them. At every stage of the progress of physics certain concepts are employed as the irreducible units or bases of things. Earth, air, fire and water served the ancients;

then came the notion of atoms in combinations, atoms of varying character. What were these atoms? how could they be distinguished? Perhaps as miniature billiard balls of different mass; or lumps, of varying shapes. Thus ideas of objects large enough for perception are projected into the wholly undiscernible region of the nearly infinitesimal. But at that stage physics did not require to worry very much about the nature of the atom any more than the arithmetician about the objects to which his numbers are applied. The importance attached to the combinations, while the varying behaviour of the different atoms was attributed to laws of affinity and the like. Ideas of that kind, though serving a purpose, are surely but tentative, and science is bound to proceed towards explanation from structure. So the modern resolution of the atom into electrons followed. But still we are left with elements which, if different, must be conceived to differ by analogy with tangible objects. Most simply conceived they would differ in shape only—which would leave us with a purely geometrical resolution. If every particle is identical unity is achieved, and no qualities whatever, other than spatial and temporal ones, need be associated with these fundamentals. If we ascribe to them elasticity for example we imply variable shape, and so negative their constant similarity. How far investigation must proceed before the final resolution is attained, if indeed it be attainable, who can say? A regression into infinity certainly suggests itself, although according to my reading, scientific men appear to be favouring a quantum theory which is opposed to infinitesimals. My present point however is that as physical science, considered as the science of the common space domain, proceeds to its goal it tends to become entirely mathematical. In so far as it does not achieve this it is tentative and imperfect.

We see then that while a common impulse and necessity of our condition leads even the untutored mind to sort out the experiences of sense perception, interpreting correlated groups of sense impressions as *objects,* and, further, generalizing into crude laws the relations subsisting between these objects and groups of objects, science is a more systematic extension of this same method, a method which in the end

resolves all things into a mathematical scheme. Now, just as I have pointed out that surveyors of differing skill and purpose might adopt wholly different methods of reducing the same field, so different minds in varying circumstances might become imbued with widely divergent conceptions of the objects of experience and their laws.

A notable instance of this changeable view has occurred within our recent experience in the promulgation of Einstein's theory of the universe, which is already superseding the older views. In this scheme time and space are regarded as capable of being brought under a higher generalization known as interval. In the old familiar view, objects retain their identity, but are subject to the flux of time. Time is an all-embracing river, carrying the universe on its breast, and witnessing ever-changing combinations of the flotsam, as it glides with even, stately movement into the abyss of the future. The objects remain the same—they merely suffer metamorphosis and displacement in the stream. The unity of Nature is expressed in this system by the conservation of matter and energy. The new theory regards Nature as a whole. The distinction of present, past and future is imposed by the observers themselves, who elevate the accident of their own position in the system to a determining factor in objective reality. We have certain limitations which at present prevent our journeying to the star Sirius for the week-end—just as we apparently have more serious ones to prevent our accepting an invitation from the Emperor Nero to a gladiatorial display—unless, indeed, there be any who are constructed after the pattern of Lewis Carroll's characters. That however is *our* affair. Nature covers *all* times and places, and exists impartially. This is the Nature of *four* dimensions—time being the fourth. WORLD LINES, instead of enduring atoms, compose this system, and an element of experience is the intersection of one of these lines with the variable superficies of an individual observer. The angle which the surface of intersection makes with the lines determines the mode of resolution into space and time elements, which thus vary.

We know how Einstein's predictions of the displacement of star light in its passage across the regions near the sun,

founded upon this scheme, were triumphantly verified last year by Dr. W. W. Campbell in his solar eclipse observations in Australia. I do not propose to attempt here any elaboration of the so-called theory of Relativity, but I instance it as showing how man's concepts of Nature and her laws are continually changing. The Greeks were our intellectual ancestors, but the sympathetic mind of the scholar is required to rescue many of their theories from what to our view seems the realm of absurdity. They placed constructions upon Nature, which seem strange to us, just as our constructions will seem strange to a future age. Einstein's theory has been described as a mathematical theory of the universe, and one finds suggestions that, for that reason, it is not a true *explanation*. The thoughts which I have attempted to develop to-night however are designed to show that the old system failed of being mathematical only where it failed of *success,* and if Einstein has made an advance in assisting to rid science of the necessity of using non-mathematical, quasi-psychological notions, that is his just triumph.

Here it may be asked, Is truth then merely a matter of mathematical convenience? Surely Nature presents something definite in apprehending which we must be either right or wrong. This indeed raises a controversial question. Professors C. D. Broad and A. S. Eddington, two of the most capable men in Great Britain in questions such as these, have raised the point in argument. Both recognize the ultimate mathematical nature of physical laws. "If," writes Eddington, "we describe the character or geometry of space throughout the world, we at the same time necessarily describe all the things in the world." Then, in another place, speaking of the apparent ultimate trend of science, he says: "We have found that where science has progressed the farthest, the mind has but regained from Nature that which the mind has put into Nature." . . . "We have found a strange foot-print on the shores of the unknown. We have devised profound theories, one after the other, to account for its origin. At last, we have succeeded in reconstructing the creature that made the foot-print. And lo! it is our own." Have we here an echo from physics of the philo-

sophical doctrine of Fichté and the subjective idealists? Professor Broad suggests that the form of analysis adopted by the mind must be conditioned in some measure by the patterns presented. If I apprehend him aright the thought is that science may be better conceived as the piecing together of a jig-saw puzzle definitely cut than the optional selection of the forms of the divisional parts.

I do not propose to enter this question further than to remark that, at all events, there is a great variety of ways in which science can survey and assess the presentations of experiences, and the only test of the truths of its formulae or laws is their efficiency and simplicity. Professor Lindemann, of Oxford, says that the old system of cosmology which made the earth the centre of the universe, is capable of explaining all the known facts. The Copernican system is merely simpler, and therefore more useful. Neither can be called UNTRUE. So it is with the new theory of relativity and the older mechanics. He says: "We find it hard to give up our prejudices. . . . To do so requires a mental effort, which, in the opinion of some, is not compensated by the gain in simplicity which results. . . . But our notions of space and time . . . are merely a matter of convenience, or even of taste. Neither standpoint can be said to be right or wrong. . . . But the old theory panders to out-worn prejudices at the expense of simplicity, whilst the new will probably seem as obvious and natural in a generation as the Copernican theory does to us to-day." One may perhaps incline to append as a proviso "if nothing better is offering." Rumour has it that Einstein himself is engaged in designing something still more comprehensive.

Following the assertion of the purely mathematical nature of a perfected physical science one may hear a protest from common sense. Mathematical formulae may do very well for text books, but surely Nature is something more solid. Can I bark my shins, for example, over a mathematical principle? In answer to this question it will be well to notice two suggestions which it raises: (1) The idea of *substance* or *reality* and (2) the import and limitations of the field of Nature as conceived by physical science.

In regard to the idea of substance or true reality, it is

a heritage from the Greeks which has permeated thought ever since. The evolution of it in the realm of science is a most interesting study which I can do little more than refer to. In effect the procedure was something as follows: Science in its development along the lines of mathematical analysis and synthesis gradually concentrated on the idea of a single common system of space and time as the container of all reality, and supposed that, behind the phenomena actually observed, was a manifold of entities, beyond the reach of observation, which, nevertheless, was the true substance or reality. As for this supposed reality, whatever its character, as it is outside all observation, it obviously cannot be subject matter of science. It has, however, laid its heavy hand upon theory, and hampered the minds of men. The materialism of the 18th and 19th centuries was largely a product of this mystic idea. It has set a sort of sacrosanct seal upon the space domain of science which well-wishers of science could very well dispense with.

But this brings me to the second point suggested to meet the difficulty of the man who damaged his limbs against the mathematical principle. Let us go back to consider the COMMON SPACE DOMAIN, the field of physical science as mentioned in the provisional definition of Nature with which I set out. This common space domain contains the subject matter of science, and is a splendid and fertile conception, but does it embrace all verities of existence? Surely not. The toothache, for example, to which most people who suffer from it will assign some claim to real existence, has no place in Nature as delimited by the common space system. Nor have the most vivid of dreams nor the space seen in a stereoscope. Yet all these things are real objects of individual experience. The fact is that there are an infinite number of space and time systems. Here we have a clue to the difference between fact of experience and fact or law of science. The former yields all that common sense demands in the matter of live absolute reality; the latter is merely logical construction.

Here then I think we can reconcile common sense with logic. The common space domain of science is not the *same* as the living individual space domains which are so mani-

fold and varied. Surely it is obvious that the latter are distinct spheres of being. The world of a perfect physical science is pure mathematics; the individual worlds, which are largely, though not exclusively, spatial contain in their systems all the real experiences of everyone. An individual space can certainly hold colour and light. The space of science tends more and more to exclude them, colour being merely form of surface, ether waves and the like. In the special spaces of individual consciousness there is no perpetual conservation of matter or energy—things disappear and never recur. There is not even complete impenetrability—the objects seen in a mirror can coincide with objects at the back of it. But while the world of a perfect physical science is pure mathematics, no physical science is as yet perfect; and the space systems of the various sciences will vary according to their degree of abstraction from the real vivid world of individual experience. Botany, for example, is quite content to admit colours, scents and so on; and I scarcely think that geology would be satisfied with a world of pure mathematics. Each science would, if it were sufficiently articulate, have its own definition of Nature, but even the least generalized science works in a system somewhat less vivid and real than the living Nature with which consciousness has direct contact. Abstraction is necessary to the formulation of laws, but while it assists, it also robs. The kind of laws which are abstracted by thought from the real experience determine the definition of the domain of Nature for that science. We see then that the term "Nature", instead of having one definite meaning, may be used in referring to a great variety of systems, ranging from the primal live experience field of the individual to the attenuated abstraction of Einstein's space-time continuum. Small wonder that controversies have arisen as a result of such a confusion!

It will be noted that the more generalized the science the more remote are its objects and laws from experience. If we say that all plants deprived of moisture will prematurely die, we express a commonly observed fact. If we say that all matter is composed of atoms, we really do not touch common experience at all, though we have enunciated a

farther-reaching law. Occasion forbids further expansion of these thoughts. I think what I have said proves that study of some philosophical subjects by any whose bent lies in that direction is called for by the times. I do not mean speculative philosophy, but sound theory of knowledge. Science has, in some departments, reached a point where happy-go-lucky basic ideas are useless. Mystic beliefs are in my opinion a human necessity—more important and fundamental to man than even science or logic. They determine *values* which science as such never can do. But surely we should strive to keep these things separate and not have a hotch-potch mixture masquerading as pure science. Philosophy has been deemed barren, but Professor Eddington has given it this testimonial: "There is no doubt," he says, "that the theory of Relativity was largely suggested by philosophic considerations." The disrepute of philosophy in the past has probably to some extent been accounted for by the fact that it was not sufficiently specialized and developed. Medical science has been distinctly down in its reputation at times. I suppose no cook a hundred years ago would take the science of dietetics very seriously. Modern exponents might be the first to recognize the justice of this. Theory of knowledge is not a difficult study, but it lags behind in development because no immediate practical good is visible. If the motor car had not been invented theories of ignition and compression would still seem to the average man merely scholastic jargon—whereas now every second youngster talks familiarly about them.

Professor A. N. Whitehead, whose work was brought to the attention of the Australasian Association for the Advancement of Science in Wellington by Mr. Miller, of Auckland, has done a great work in exposing the fallacy that scientific laws and entities are the real data of experience, and in opening up fields for investigation. I recommend his book *The Concept of Nature* to the study of everybody interested. Perhaps some will criticize what I have said on the ground that there has been confusion between the physical and the mental world. I think however that I may place the confusion elsewhere. Professor Whitehead, while recognizing a true region of thought apart from Nature, is

concerned to emphasize at great length the blunder of what he calls the bi-furcation of Nature, or division of the objective world into the mental and the physical, secondary qualities being relegated to the realm of the mental. The essence of my contention in this paper is that Nature, in the interpretation of science, is a limited sphere of varying definition according to the degree of abstraction from the real world of individual consciousness which the system of laws used by any particular science demands. In perfection it would correspond to a kind of index to the great cyclopedia of conscious experience. In comparison with the varied articles of the text such an index is orderly and methodical, the essence of law and order, but it is nevertheless bare and lifeless. Whitehead is disposed to bring the use of the term Nature back to its more concrete significance. "The Nature," he says, "which is the fact apprehended, holds within it the greenness of trees, the song of birds, the warmth of the sun, the hardness of the chairs and the feel of the velvet. We are instinctively willing to believe that by due attention more can be found in Nature than that which is observed at first sight. BUT WE WILL NOT BE CONTENT WITH LESS!"

To sum up, I have endeavoured to show that the objects forming the content of perception at a given time, while they certainly owe a debt to a constructive mental element involving class and relation, are nevertheless in a sense the true elements of reality. There are, at least, as many such fields of reality as there are persons and times. The various sciences, according to their degree of generalization, abstract from these real systems, classifications and relations, and laws, which are forthwith consolidated into suppositious space systems more or less vivid according as they are nearer, or farther removed from, the original reality of conscious experience. As law becomes simplified and generalized we approach a system from which all colour and sense content is banished and in its place is a field of pure mathematics. The approach to this stage must, if fallacies and difficulties are to be avoided, be accompanied by a sound and explicit epistemology or theory of knowledge.

V.

THE HUMAN AND NATIONAL VALUE OF ASTRONOMY*

Mr. Chairman, Ladies, and Gentlemen,—

At last Annual Meeting, in my absence, you did me the honour of electing me as one of your Vice-Presidents, and I take this, the first, opportunity of thanking you. It is no small privilege to take part in the proceedings of these first years of the N.Z. Astronomical Society, for, although it is in a comparatively small way as yet, I feel that we are witnessing the commencement of what will in time to come prove to be a great and historic association.

I hope to say something in support of the proposal to establish a Dominion Observatory, for I think the time has undoubtedly arrived when New Zealand should take a definite forward step in astronomical work. The Yale proposal has aroused our ambitions, and, although that scheme has passed us, we must not allow the progressive impulse to come to nothing, and relapse into a state of apathy in this important department of science. We need an observatory worthy of the Dominion, and in keeping with our international duty and geographical privileges.

However, I do not desire to confine myself this evening solely to dry propaganda. Will you allow me, therefore, to examine briefly the general purport of astronomy from a broad human standpoint. I do not profess qualifications enabling me to elaborate a technical examination; but perhaps that is an advantage in one respect. The professional scientist, to whom we for the most part look for our technical knowledge, is often a specialist who has to fight a possible tendency to regard the trees rather than the wood as a whole. The amateur, like myself, is not so much beset with this temptation; so perhaps it is well that he should occasionally have his say to those who are indulgent enough to listen to him.

* Supplement to *Southern Stars*, journal of N.Z. Astronomical Society. (Address to Annual Meeting, 12th November, 1924.)

On its merits astronomy will not suffer in repute by being weighed in the balance of human and national values. First of all let us inquire what is the impulse which sets man on to study the heavens, what methods have been applied, and what is the final aim, if, indeed, we can speak of finality in this connection.

The impulse is primarily the general impulse of science, namely to unify and systematize the phenomena which we see around us. And is it conceivable that men could, for long, witness the ceaseless procession of the life-giving sun, the stately moon, and the starry host without endeavouring to link them up with earthly affairs?

As to methods, we know that in ancient and mediævval times the link was often of a very mystic character, as evidenced by the vogue of astrology. We must not be too harsh in our criticism of this. The human mind has an ineradicable tendency to seek causes, and what more natural than to attribute the incomprehensible fluctuations of human fortune to the unperturbed dome above, where the stars, in their varying orders, traverse their majestic cycles, the discovery of which it was believed would disclose much about the fate of mortals? Comets and meteors, too, were the obvious messengers from above, and it was a simple matter to connect them with changes and disasters which are going on fairly continuously among men.

Alongside astrological speculations, however, a great deal of real knowledge of the heavens was accumulated. It is exceedingly difficult to say how much, and one notices that cautious historians are not very definite about it. It must be remembered that in ancient times transport and communications were slow, and the world was divided, so much might be going on that was never communicated to the recorders upon whom we depend for our knowledge.

I think that commonly a great deal of misconception exists as to discovery. From some school books and popular literature the impression might be gathered that Galileo, or perhaps Columbus, was the first to imagine that the world was round; but there is no doubt that this idea must have been familiar to many of the ancients, one of whom,

Ptolemy, early in the Christian era, gave a very approximate estimate of its circumference. The mass of people, engaged in other pursuits, would not pay much attention to the speculators, but very probably these matters were keenly argued about by the sages.

Also as regards the solar system, it may reasonably enough be surmised that the idea of a heliocentric system had been at least conceived by some of the wise men of old (and it really was so conceived by Aristarchus of Samos), although, of course, we rightly give credit for it to Copernicus, whose great work we know to be for us the beginning of the development of that epoch-making discovery.

Ptolemy of Alexandria, by the great weight of his influence, and by his clever mathematics, seems to have brought about general acceptance of a geocentric scheme to explain the apparent movements of the sun, moon, and planets, and this tradition was not broken along the line of our historical records till the time of Copernicus, whose theory, confirmed by Galileo's telescope, gained general acceptance.

In looking back we are apt to wonder what all these acute observers and mathematicians were thinking about in failing to interpret the obvious facts. Many of these ancient astronomers were certainly as acute and as painstaking as the most able men of to-day. The human brain cannot have developed very much intrinsically, and I suppose that if a Greek baby, born, say, 2,500 years ago, had somehow or other been subjected to a Rip Van Winkle sleep till the present day, he would, if he retained his babyhood till awakening, grow up indistinguishable, except perhaps by superiority, from the men of this generation. Conversely, if a child of our day could be transported back through the ages, he would grow up with the old-time ideas.

We, of course, are habituated from early youth to the idea of a round earth circulating as one of the planets round the sun, and that forms a foundation—although in many people the superstructure is of a rather vague order. But eliminate this communicated knowledge, and try to imagine the problem presented by the skies if viewed from a totally unsophisticated standpoint. One would, just as our fore-

fathers did, almost certainly make a general division of nature into two parts—namely, the *heavens* and the *earth;* only I think there would be a tendency to put the earth first, as the senior partner, and relegate the heavens to second place. So we make our classification by the human standard, much as a certain famous pill inventor divided people into two classes—those who *used* his pills, and those who didn't—for which we don't blame him, because, from the point of view of his business, that was the important distinction.

But, as we have acknowledged the heavens as at least of secondary interest, how are we going to construe their phenomena?

It would be interesting to know what explanations and myths would have arisen if the pioneers in astronomy had lived, not in fairly low latitudes, but in the polar regions, where the sequence of night and day and the passage of the sun and stars overhead would be replaced by a kind of merry-go-round, with the sun, moon, and planets making seasonal apparitions of considerable duration above the horizon, circling horizontally round the skies, among the unvarying star patterns which adorned the revolving dome, and sinking away again to the unknown. For the modern student the consideration of such a position simplifies many astronomical problems and conceptions. At the pole the equatorial telescope becomes an alt-azimuth; *declination* and *altitude* become identical, while *right ascension, azimuth,* and *hour angle* fit naturally into each other. For the ancients, as the whole revolution of the bodies would be visible, no mystery would be presented regarding the nightly transport in the nether regions from west to east.

All these problems had to be faced by the Chaldeans and Greeks approximately from the position in which they were placed by nature; for they had not explored the ends of the earth—or, indeed, very far from home. The primal idea would doubtless assign to the sky a dome shape, with the heavenly bodies spread out as if on one surface. The old myths confirm this supposition, for it was common to think of one object swallowing another, the moon, for example, swallowing a star or planet at an occultation. Of course such

a procedure would be highly unsatisfactory for the moon if the star happened to be a few hundred light years farther away! Quite effective rough instruments, such as the gnomon, were devised to trace the track of sun, moon, and planets among the stars; for it soon became known that these objects moved against the apparently fixed patterns of the revolving star sphere. It must have taken a little thought to discover that the sun did not really *melt* the stars out as he rose in his glory and outshone them into invisibility. However that may be, undoubtedly the sequence of eclipses became well-known to many of the astronomers.

At what stage the application of the idea of solidity and varying distance became firmly recognized, it would, I suppose, be impossible to say; but it was certainly a live question some hundreds of years B.C., and the geocentric theory of Ptolemy showed a complete development of it as far as the solar system was concerned.

This same geocentric thought persisted in the great sixteenth century genius, Tycho Brahe, who, over a millennium later, and still working without telescopes, succeeded, by the use of large circles and the exercise of mechanical and intellectual skill, in working out a great deal of accurate information about the position and movements of the heavenly bodies. Copernicus, followed by Galileo with his telescope, and Kepler, brought in the new era in which the earth is regarded as moving in the same manner as the other planets round the central sun. In considering this transition epoch, and the whole aspect of the moving earth discovery, we must remember the tremendous difficulties in the way of acceptance of the new doctrine. It was not stubbornness only. In the first place the earth was the symbol and standard of all that is steadfast, and to say that it moved seemed merely a sacrifice of plain and fundamental fact to satisfy questionable speculation. Then again gravity was not understood. People believed in up and down directions in space, while relative sizes were not appreciated. How was it conceivable that the great earth would roll along an erratic course in the sky, sometimes upwards and sometimes downwards? Then if it moved round the sun, Tycho, at least, knew quite well that it must traverse an immense distance

in space, and the stars ought to seem displaced, just as the profile of the Southern Alps changes as we move in the train across the Canterbury Plains. But they were not displaced. Hence he dismissed the whole theory as unbelievable. However, with that great new weapon, the telescope, Galileo was able to prevail. Then followed Newton, who, by the magic of a single conception inspired by genius—namely, the law of universal gravitation, swept aside all difficulties and made the solar system an intelligible and consistent unit.

This was a mighty step forward. In place of the single earth as the starting point and base of speculation, was now a related family of bodies of which the earth merely made one.

But the human mind, ever unsatisfied, sought a further unification of the beyond with the known. The so-called fixed stars still confronted the astronomer, and were thought of as lying on one surface in the far distance.

The problem was thus merely shifted one step back and remained otherwise as before. Would it be possible to bring even these mysterious bodies into the working model of worlds now being mentally constructed?

This brings us down to modern times when Sir W. Herschell and his son, Sir John Herschell, late in the eighteenth and early in the nineteenth centuries, performed such magnificent work in surveying the sky and recording the deliverance of their telescopes concerning the great starry belt of the Galaxy, or Milky Way, whose form they did much to define. The solar system now appears as merely one member of a stupendous star system which is again subdivided into groups, clusters, and weird nebulæ in bewildering profusion. What an immense step into space, this! And at last some relative motion was detected in the stars: also the first discovery of doubles with mutual movement was recorded. Still, in spite of brave attempts of Sir John Herschell, with his telescope at the Cape Observatory, no trace of parallax in any star could be detected—that is, movement against the background of the celestial dome as the earth traverses the great sweep of its orbit with a diameter of, say, 186,000,000 miles. Here would be a clue

to stellar distances, provided these distances were greatly diverse as was now assuredly thought, but the stars experimented upon gave no sign to Herschell.

This conquest remained for the German mathematician and astronomer, Bessel, who in 1838, working with improved instruments, found a parallactic displacement in the star 61 Cygni of 4/10th of a second of arc. The immense distance of the stars now stood revealed, that of 61 Cygni working out to about 40 billions of miles.. But, great as these distances might be, a method of dealing with them had now been found, and although that method might be beset with difficulties and might hold out little prospect as far as the great bulk of the stars were concerned, hope gleamed again, and that hope has been justified by subsequent events.

Visual work at the parallax problem proved exceedingly difficult and limited in its scope, but a new ally was at hand in the emergence of photography. The sensitized plate was perfected, lenses were adapted for refined work, and measuring apparatus of the most careful construction and design were employed to carry on the work. At the present time, largely as a result of work done by the Americans, the parallax of a long and expanding list of stars has been determined, and the work is still going on.

In considering the work of the spectroscope, the great modern instrument of stellar research, it must be remembered that, great as its achievements are, the results have been inestimably aided by former parallax work. One set of determinations, like the base of a topographical survey, gives the foundation for further advances from point to point in an ever widening sweep. The greater the new knowledge the greater the potentiality for future advance.

The spectroscope, by its analysis of the light waves received from the observed object, has enabled motions of approach or recession of stars to be measured; it has given us certain knowledge concerning their matter constituents, and now, by its aid, the actual distance of immensely remote stars and clusters is being computed. The method by which this last feat can be performed may be suggested thus:—Stars have come to be recognized as of definite types. A

course of evolution has been laid down for them, but, whether that course is universally followed or not, the fact remains that the spectrum gives the clue to the type of the star and consequently to its absolute brightness. That is an intrinsic quality not dependent on distance, as is apparent brightness or the ordinary magnitude assigned to stars. Now, if a man were, on a dark night, viewing a scene over which were dotted a number of lights, but which was otherwise quite featureless to the eye, he would be at a loss to distinguish with certainty the distant lights from the near ones, if they varied merely in intensity. But if he knew that certain ones were glow-worms, others candles, others motor headlights, and others electric arc lights, he would at once have the clue to their distance. Or if, looking at a field through a window, a fly on the glass were mistaken for a horse in the field (a thing easily done at first glance), the mistake would be at once detected and the true distance of the fly known as soon as it was recognized by the shape to be a fly and not a horse. So with the stars: given their absolute or intrinsic brightness (discoverable by the quality of their light shown in the spectroscope), the distance can be estimated from the *apparent* brightness, because the law of diminution of brightness with increasing distance is well known.

It was recently found that certain variable stars called Cepheids exhibited an absolute average brightness definitely related to their period of variation. Of course the period of variation is easily observed, and the absolute average brightness being deduced therefrom, and the apparent average brightness observed, the distance follows by calculation. This has afforded a means of measuring the distance of the great cluster in Hercules, which contains many of these Cepheids. The distance comes out at 36,000 light years.

Star clusters and nebulæ were, until last century, confused a good deal, but the large telescope and the spectroscope have made a clear distinction. Globular clusters are great systems containing tens of thousands of stars or suns bright as, or brighter than, our sun, though the whole cluster looks to the naked eye like one faint star. The

nebulæ, shown to emit light indicative of a gaseous origin, are now being regarded by a new conception arising largely from the discovery of dark nebulæ which obscure the background of stars. Here, again, is something new in the heavens. We know a good deal about terrestrial dust, but there is a dust of space, exquisitely fine and actually blown about by the pressure of light rays, which latter are now regarded as offering strong competition with gravity as the controlling force in some large attenuated stellar bodies. It is a common observation that leaves, during a wind storm, collect in sheltered places such as tents or marquees. Similarly the drifting celestial dust accumulates in vast interstellar tracts where the cosmic forces of light pressure and gravitation are in approximate equilibrium, and here on some portions dim light may pervade the nebula, or, on the other hand, it may remain dark and black. The amount of illumination has been found to be proportional to the light of the stars near or in the region. The light is thought to be either directly reflected to us or re-emitted after absorption by the nebulæ dust. The emitted light indicates a gaseous origin because (so the theory states) each particle of cosmic dust carries a molecule of gas.

And so, from the space of a sky dome thought to be subsidiary to our earth, the universe, grasped at by the mind of man, has expanded before the attack, and revealed itself in its amazing dimensions. The Galaxy (the Milky Way), or our all-inclusive star system, is estimated by Shapley to be 300,000 light years in length. And when this has all been summed up we have to reckon with the fact that away round what was thought to be the empty outskirts of our sky are now revealed to the photographic telescope thousands of strange objects known as spiral nebulæ which are thought by some to represent other Galaxies at inconceivable distances away in the void. This, however, is a debatable point, and it may turn out that these, too, are included in our great system, which of itself may be a lonely unit facing the measureless gulf beyond.*

Are we now at the limit? Will human devices carry a future generation farther and exhibit the contents of these

* They are now known to be separate systems.

regions away over the edge of our remotest thought? Who shall deny the possibility?

The mind is staggered, and we take some consolation from the Relativity theory which reveals the possibility of a final limit so far as even the vastest human conception of physical movement can span. The age-long traveller on the wings of light may traverse every nook and cranny of space and there will be nothing left for him but to return to the place from which he came. At last the physical universe is one and complete, just as to an ant creeping on a ball there is no barrier yet the domain is finite. But is it? That is a dream. To say nothing of the downward infinity by way of the atom and the electron, *imagination* can leap even Einstein's barrier, and think of other and different spaces and time systems beyond.

No, the final mystery will always remain, and it is foolish to expect science to answer it. Not from the *weakness of science,* but from the nature of the case that is impossible. Mach, a Continental physicist of last century, considered rather an erratic by his generation, but now hailed as one of the prophets of modern physics, said that the object of science was the resolution, not of the unintelligible to the intelligible, but of *uncommon* unintelligibilities to *common* unintelligibilities. I read just the other day of Lord Kelvin that he did not consider he understood a thing till he could reduce it to a mechanical model. That is it. We reduce things to a mechanical model, but the pristine unintelligibility of the model remains. Mach calls it the common unintelligibility. He says that we are satisfied when we understand things in terms of contact and pressure, postulating the impenetrability of matter. For my part I see no a priori reason why matter should be impenetrable. If two billiard balls meet, why should they not pass through each other and continue on their courses? If you speak of collisions of electrons as debarring it you are merely shifting the problem into a misty region, but not touching the *essence* of it.

In gravitation, as Mach pointed out, it seems that we must depart from contact causation unless we somewhat ineffectively interpose the ether or radiation entities. No

longer, said Mach, do we resent Newton's gravitation hypothesis, because we are now accepting it as a *common* unintelligibility, and that is all we require. I suppose no one would now assert that gravitation will be assuredly reduced to a contact phenomenon. Relativists, of course, deny the necessity or utility of that. Still, by all means, let us, with a very good will, wish success to those who would try to do it. Astronomy, I think, helps us to discern how conceptions and the manner of viewing things change as the ages roll. A purely modern mind, in looking back to Plato, Aristotle, and the great minds of old, unless there is some exercise of constructive and sympathetic imagination, is liable to say, What nonsense they talk! Probably a thousand years hence our successors will be tempted to so regard our great men. Many things, including temperament, exercise an influence on the conceptual forms which we apply even in science to the universe around us, and what vandal would wipe out the picturesqueness of individuality?

Was it not Aristotle who held that the circle was the perfect figure, therefore if the planets do not seem to move in circles beware of being deceived by appearance! We of modern times, following Newton, have said that ideally objects ought to carry on in straight line movements, although probably no one has ever seen an object moving in a perfectly straight line, while very few move even approximately straight. If the planets move in ellipses then certainly some demon, let us call it Gravity, is pushing them out of their courses. At all events they must render an account of their departure from our nicely worked out scheme! O Aristotle (like Julius Cæsar), thou art mighty yet! Still, new concepts must not divert scientists from using the old ones to the full extent. There is plenty of scope for all.

I now come more closely to the question of the value of astronomy. In doing so one must recognize that a scale of values requires a basis. If we ascend the scale of animal life we would probably find that the objects valued vary along a corresponding scale. To the mouse a piece of cheese, to the donkey a thistle, to the dog an exciting chase, to man all sorts of things according to individuality, take the pride of place for value.

To one man a picture-show, to another a horse race, to another a beautiful garden, to another the excitement of public life, to another refined music, to others science in different departments, and so on. Most people would, I think, agree in a general way, however they might in practice ignore it, that what tends to a fuller mental and spiritual life is good. It is well to promote and engage in things which off-set the tendency to lapse back on mere sense and physical luxury. Many things, of course, do this, and no one thing can claim a monopoly. But in my opinion, as regards the expansion of important spiritual faculties, nothing could quite take the place of the feeling liberated by contemplation of the vast starry hosts of heaven and the immensity which surrounds them. Most people, apart altogether from systematic study, experience this in a degree. I wonder what sort of a world it would be if clouds perpetually veiled the skies. Even then, of course, imagination would reach beyond them, but the sense of vastness would have less to support it.

It is a significant fact that the great spiritual impulses of the world have come from the regions where the sky is usually clear; and if we take Hebrew Scriptures as a guide, frequent references, many of them of sublime beauty, demonstrate the impression made by the sun, moon, and stars upon the people of these times. Since then, poets and prophets of later ages have drawn inspiration from the same sources. Also the *philosopher*—" Two things," said Kant in an oft-quoted passage, " fill me with wonder—the starry heavens above and the moral law within." Here we have a man, believed by many to be the greatest philosopher in history, weighing together the starry heavens and the moral law. Who shall gainsay then the value of study in this sublime sphere? And I think it can safely be affirmed that the closer acquaintance of study does not belie casual impressions. On the contrary, the universal testimony is that the fascination is enhanced many-fold. Faint spots expand in the telescope to gigantic star systems, leaving us at a loss for a unit of magnitude by which to comprehend them. Points of light, too small to exhibit any shape to the unaided eye, open up into discs which, as we attempt to read their

marvels, seem to enlighten us as to the history and nature of our own world, while the moon with its rugged heights and shady valleys (as it were a mummified world) forecasts the future when this earth shall have served to the end its day and generation as the home of men.

Then we think of the sun to which we look perpetually for life and sustenance; while many problems about this, our physical parent, remain to be solved, we at least have the assurance that energy, heat, and light abound in such prodigality that we need have no fear of his failing us or our descendants for untold generations. Would we be ignorant of these things? And, if we would, can we not appreciate the superb play of expectation, uncertainty, achievement, and new marvels which, attending the life of astronomical investigators as by gradual stages they worked out into the realms of space, has been reflected more or less as a universal asset to all human minds not absolutely incapable of uplifting sentiment.

Wait! says the inevitable objector, these panegyrics are all very well; but what actual benefit have we received materially from astronomy? Let us see, then. I assume that science in general is recognized as beneficial. That may not be absolutely beyond the cavil of some, but practically everybody admits it nowadays. If we examine the history of science no very deep probing is required to see the important, we might say indispensable, part which has been taken by astronomy. Although the influence is all-pervading and cannot be assessed fully by detail, we will nevertheless take some concrete illustrations and instances.

First: What would have become of physical science in the absence of effective mathematics? Astronomy owes a debt to mathematics, but assuredly also the science of mathematics owes a debt to astronomy. What stimulated Newton and Leibnitz in the discovery of the Infinitesimal Calculus? Was it not the need for mathematical method of dealing with astronomical problems; and without the Calculus how would physics—and in turn modern industry—have fared? At many other points along the line of mathematical advance astronomy has been a stimulating and guiding influence.

But to come to something more material still, this time in the realm of chemistry and physics. It was the astronomer who discovered a strange line in the familiar solar spectrum, and thus became aware of the new element helium. This was followed by a look-out for the element on earth, and before long it duly turned up, and is now available for use. Helium is a very light gas, and is capable of efficiently taking the place of hydrogen for balloons and airships, with the additional advantage that it is not inflammable. This means that airships can now be constructed, both for peace and for war purposes, which are not liable to be exploded and burnt. In view of recent feats of airships, notably the trans-continental voyage of the American vessel*, it is difficult to say what future may be before these craft, and what service they will render to man. Without helium, which probably would be still undiscovered apart from solar research, such craft would always be subject to the danger inseparably attaching to hydrogen, and would probably have brought about accidents and deaths innumerable, if, indeed, they were not abandoned altogether as too deadly. But we are not yet at the end of the benefits conferred by helium. It has turned out to be closely associated with the process of atomic disintegration, and knowledge of its existence in the sun, and its characteristic behaviour under the enormous temperatures and violent conditions obtaining there, may very well prove just the necessary guide to the physicist in his battle with the atom, the upshot of which bids fair to usher in the most revolutionary advance in physical science to which optimists are looking forward to-day.

We must consider, too, in reference to the new atom theory that the results of astronomy have been drawn upon in the conception of the atom as a minor solar system consisting of a nucleus and attendant revolving electrons. Genius was necessary to arrive at this conception. But would even genius itself have succeeded if the analogy of the circling planets had not been made a familiar picture as a result of the long and arduous work of men devoted to the study of the skies?

* The huge hydrogen-inflated "Shenandoah" tragically lost in flight.

The plain and now unquestioned fact is that astronomy and astrophysics form an essential branch of the science of physics, and the opportunities which they afford for examining the processes of Nature, cannot be ignored without stultifying and retarding the advance of that knowledge of force and matter which is essential to the maintenance of an advanced position by any people. Experiments which can be performed with great difficulty under puny and cramped conditions, or which are impossible altogether by the aid of any forces under the control of man, have their counterpart on a gigantic scale in the great laboratory of Nature, and are to be seen for the mere looking. Yet we can grudge the cost of the glasses and apparatus with which to view them and record the invaluable results!

Electric and magnetic phenomena on a vast scale are going on in the sun and stars, and much must surely be of interest to our physicists who are carrying on researches designed to track these phenomena to the sources of their power.

All this is important to people who are interested in science, but it has also, without doubt, a *national* bearing.

Many individuals make the nation. What national benefits has New Zealand derived, or can she derive, from astronomy? I think we can commence with a very important one.

When Captain Cook made the first voyage in which he explored the New Zealand coast, geographical discovery was not the first object of the expedition. That object was none other than astronomical observation; for he was sent by the British Government to observe a transit of Venus in Tahiti. It was important astronomically to observe this phenomenon because the time of apparent contact of the planet with the sun's disc was expected to yield much desired data in the problem of the solar parallax, involving the distance from earth to sun, which would provide a most useful fundamental unit in celestial measurements. Further, even if geographical discovery had been the prime motive, the voyage would have been practically impossible without astronomical knowledge; and if, by some chance, it had

been made the results would have been vague in the extreme, for no positions or coast lines could have been recorded.

Here, then, we have the fact that if Britain had not been astronomically progressive, some other country would probably have annexed New Zealand, if, indeed, the Maoris were ever disturbed at all.

Consider again three indispensable services rendered to the State by astronomy, in its aids to navigation and surveys and in its standards of time keeping. From the earliest times ships were guided by the stars. I remember that in hearing this as a boy I used to think that the stars must have proved rather treacherous guides in view of their circling movements. Of course in the north the steadfast pole star would doubtless be a tower of strength. The manner in which stars fix a position is best understood, I think, by imagining for a moment how the skies would appear if the earth were motionless in space. Then each place on sea and land would have its own star; that is to say the star overhead would always be overhead, and each star would be catalogued with its earthly counterpart. The experienced skipper could simply cast his eye up the mast, or its instrumental equivalent, pick his zenith star, and refer to his list, if, indeed, his memory did not serve to identify it.

As a result of the earth's rotation no place save the North and South Poles is identified by a point in the sky, but is associated with a circle which its zenith describes round the celestial pole. This circle, and consequently the latitude, is almost as easily identified as a definite point or star would be; but extra trouble is involved in finding which of the long line of places under that circle the observer is occupying. This is the longitude problem, and it cannot be solved without some considerable astronomical calculation dependent on the work of observatories—notably the time service.

In surveys the stars are again the fundamental points of reference, and a permanently obscured sky would involve a radical change in the whole method of survey. Indeed, complete surveys would be practically impossible, for the whole world would require to be triangulated up into one system.

An old law forbids the removing of a neighbour's landmark, but the stars provide means for making these landmarks secure against caprice. Then, again, we derive our time system entirely from astronomical data, an absolutely indispensable service.

Another valuable function of astronomy is that it creates an intellectual link between nations, and so makes for international goodwill and unity. Other sciences, of course, do this also, but none is freer from the elements of jealousy or suspicion. The promotion of an intellectual brotherhood is a most worthy objective.

Something has been expected of sport in the way of the promotion of international fellow-feeling, but the Olympic Games have resulted in rather a blow to that theory. Science, I feel sure, has more hope of success, especially a science detached from destructive aims. Observatories are needed in the southern skies. Northern astronomers have often deplored the lack of them. Indeed, northerners have themselves done much of the work that has been done in the south. Of course we do not expect so much from the new countries of the south, for the population is sparser.

New Zealand is not in its infancy now. We pride ourselves on being a Dominion, in taking our independent share in the politics and work of the world. Are we then going to rely on other people to supply us with the elements of advance and culture to which every nation should itself contribute its share? That would be a spirit unworthy of this country. And this is the reply to those who say "Let other countries do this work for us."

Last night and this morning I had an opportunity by the courtesy of Dr. Adams of seeing the fine nine-inch refracting telescope provided in Wellington by the City Council, and I feel that Wellington City is to be congratulated upon this enterprise. It is a beautifully equipped instrument, and I feel sure that the city is proud of it. I hope it will do great service in promoting a public interest in the science which our society exists to support.

But we require not only local effort. We want a first-class national institution. Our geographical position imposes that duty upon us.

It is gratifying that the Government is now moving to test sites throughout New Zealand. Although we in Otago have great confidence that we have splendid sites and splendid skies, and though our people are ready to co-operate heartily in this scheme, if, after sound tests, any other place should prove more suitable, we will be perfectly satisfied that the observatory should be put there. It is not my intention to-night to suggest detailed schemes. No doubt the N.Z.A.S. will assist the Government and the Government Astronomer to the fullest extent in formulating a scheme.

Personally I think that if the Government would undertake the carrying on of the Institution, private individuals and local institutions would do their share towards building and efficiently equipping the observatory.

An excellent telescope on a par with the Yale instrument, mounted and equipped with accessories and housed in a substantial building with the necessary conveniences for observing and observers, and probably including residence, could be secured for about £20,000.

Eight thousand pounds was the amount Yale proposed to spend on its fine telescope equipment. Well, Africa is to get that; but what does it amount to?—the price of about a score of motor cars which may be seen parked around any small city block or country township. We deplored the loss of the Yale telescope. Cannot we raise the amount to replace it?

I feel sure that New Zealand, following the fine example of the Dominion of Canada, can, and eventually will, do this thing.

VI.

PHYSICAL SCIENCE AND PRIMARY EXPERIENCE*

If a missile, say this book, were suddenly flung at the window pane, the vivid perception of breaking glass common to all present, as contrasted with the train of superadded ideas and impulses varying in each one of us, would typify the common domain of physical Nature lying over against the fuller world of primary individual experience. Confusion in respect to the boundaries of these two realms is, I think, a competitor with the canonization of language for prime position as the root of futile excursions in philosophy.

For the reckless experiment suggested, however, the last book I should use would be the one I hold in my hand, *The Nature of the Physical World,* by Professor A. S. Eddington, of Cambridge, in which the character and interaction of the two spheres are discussed with such acuteness and charm.

In the dawning philosophy of the ancients, the problem of the " public " and " private " worlds did not exist; the universe for contemplation was simply " there ". The concept " there " became, in time, too vague for nascent science, and the metrics of Descartes, combined with his dualism, opened the way for advance to the modern mathematical conception of the four-dimensional extensive continuum Nature, from which all lingering psychic elements, such as colour, force, etc., have been gradually banished. Thus the physical concept would seem to have achieved its ultimate logical purity. Not many philosophers would expect, like the old materialists, to find in this purified physical scheme the foundation of all things; but it may be profitable to inquire how far the expectation, still implicit in much current thought, of finding a physical base, correlate with each feature of our direct personal experience, is based on reason, and how far it is due to a widespread failure to

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distingush the field of Nature, as a common domain of conceptual thought, from the direct primary impacts which attend and constitute the stream of conscious life. I propose to illustrate this point by a brief examination of three topics prominent in Eddington's book: (1) What I may call modern Rip Van Winkleism, (2) "Time's arrow", and (3) the partial indeterminism of Nature.

(1) *Modern Rip Van Winkleism.*—A law of relativity physics prescribes that the rate of a clock in motion is slower as reckoned from the point of view of a stationary clock. Therefore a man, says Eddington, by adventuring into space at enormous velocity (beyond present human ingenuity), could in a few hours, as shown by his own watch, live for a period which would transform his youthful contemporaries of earth into old men. All his physical processes, and presumably the lapse of his conscious time, would stagnate (in the terrestial view) in sympathy with his watch; so, actually, he would be projecting his life into a new epoch. Travel to the distant stars, hitherto ruled out on the single ground that the utmost velocity would not enable a man to complete the journey in a lifetime, would, at least in respect to this restriction, again become possible, because the supertraveller would not necessarily, by his own time, spend in transit a sufficient period to become aged, or even cold and hungry.

For the purposes of this argument, I am accepting the high authority of Eddington on the physical truth of this doctrine. Difficulties which he himself suggests are not cleared up altogether in my mind by his footnote on page 27 in *Space, Time, and Gravitation.* In any case the broad principle stands. The point to note is that in the bizarre situation suggested the stationary man assigns the supertraveller a span of life different from his own, and *vice versa.* Also, any given period of life which might normally coincide, say their fiftieth birthday, would not be regarded by either as simultaneous. There is, in fact, no general cosmic time, but only relative time. As regards my main inquiry, the relevant feature is that by physical laws we assess, not merely physical events, but the contemporaneousness of other minds and personal histories.

Now, while we need not be overmuch concerned about the convenient method of setting or reading clocks, there is an intense differentiation between our attitude towards what we believe, for example, to be *present* suffering and suffering in remote ages. It would be difficult to believe that a sigh of relief, elicited when an untoward experience of a friend is, as we say, over and done with, has no sort of justification other than that founded upon our peculiar point of view. We may, of course, be utterly deceived in imagining that there is such a thing as a veritable contemporaneousness of minds, because the rational foundation of the idea seems lacking. But, taking the almost irresistible intuitive view of its reality, it must find its basis, not in physical expression, which can yield us only the relative and variable, but in a detached realm of personality and non-metric experience. Be it noted, however, that the dilemma would never occur for a single mind, in which simultaneity of experience is absolute. It occurs only when we attempt, necessarily, but not rationally, to yoke separate minds with the flux of a single physical Nature in which all our bodies are inextricably involved.

The problem is not solely a Relativity one; it would occur in any scheme of physics. If, with superb telescopic vision, we could see in the so-called spiral nebula of Andromeda a world peopled as with intimate neighbours, we should, if accepting the classical theory of the finite velocity of light, be compelled to believe that the scene was merely a mimic reproduction of what happened nearly a million years ago. It is now fairly widely admitted that the laws of Nature can be construed in many diverse ways, the dominant system being merely the simplest for our intelligence. Hence, just as the geocentric planetary system of Ptolemy could be upheld against the Copernican innovation if simplicity were of no account, so a scheme of physics postulating an infinite velocity of light is discarded only because of the hopeless complexity involved. In such a system, however, the Andromedans would be our true contemporaries. Could we judge such a vital matter indifferently according to our predilection for a certain optional physical theory?

" Time's Arrow ".—This term is used by Eddington in connection with a certain character which he wishes to impose upon four-dimensional Nature. My comments are directed, not against the attendant circumstances leading to this imposition, but to mark the implied departure from the strict physical scheme in the purity which it seemed to have attained.

Until recent times science worked with a three-dimensional Nature, which, by its adventuring in time, exhibited a certain dynamical character lacking in Minkowski's four-dimensional extensive continuum now made famous in the physics of Einstein, wherein " the formality of *taking place* " seems to be ignored. A frequently used illustration of this four-dimensional world, in which time ceases to be a detached, somewhat nebulous entity, and becomes a definite dimension, is taken from the cinema film. If the progressive pictures on the reel were separated, and superimposed in order, a block would be formed in which time would be represented in the thickness of the block. The unavoidable suppression of the third dimension on the single film leaves the way clear for its inclusion as temporal expression. We cannot illustrate with a perfect counterpart, because we always require a spare dimension in which to move round a model. If our make-up consisted of two dimensions only, we could deal with lines, but not with areas, to scan which a third dimension would be necessary. Similarly, we can use three-dimensional models because the fourth (time) is free. Two facts—(1) that our extended conceptual ideation cannot exceed four dimensions, and (2), that in the past, science has demanded models—probably explain the long failure of man to recognize time as an ingredient dimension in Nature. Its introduction has necessitated the abandonment of full models, and the substitution, to a large extent, of mathematical method founded on metrical quantities.

In the block cinema we have the history of a scene from one point of view, namely, that in which the camera was situated. In the Nature depicted by atomic physics (which is in essence abstract), each particular film section would be deprived of its vivid and intimate character, and would present instead the relevant characteristics of all points of

observation symbolized as an assemblage of dots. These dots would be projected in the compact block as continuous lines, the intersections of which fix in temporal order the clash of atoms, presumed, in older theory, to underlie all physical phenomena. I waive the relativity conception that the lamination into individual films, depicting instantaneous segments, would not be fixed, but might lie at varying oblique angles. The variation would be within strict limits, and the general principle is not vitally affected.

Eddington notes in Nature a process analogous to the shuffling of cards. If the arranged order of a new pack be disturbed by a shuffle, the extreme improbability that further random shuffling will restore the original order is so great as to amount practically to an impossibility. The measure of this steady advance in Nature to random distribution is embodied in a law of thermodynamics, and is expressed by the term, entropy. While entropy continually increases, the effective energy in the world runs down after the manner of a clock. Hence the inevitable doom of Nature is predicted. This is a most interesting and momentous theory, upon which at present I suggest only one comment. The shuffled pack possesses as definite an order as the new pack, although not so simple to our cognitive faculties. Does Nature, then, *really* display a special recognition of simplicity as we construe it? Although the ordered condition in the pack appeals uniquely to our minds, the return to *any one* random state is equally improbable. In placing the antithesis between the ordered and the disordered we are setting unity, or minority, against the multitude, rather than one against any other single condition. However, as Eddington assures us, the progression towards the random is definite and calculable, and this progression marks in Nature a distinct direction into the future, which direction should be marked with an arrow in the time dimension to show that it is a one-way road, thus contrasting with the space dimensions in which right or left, back or forward, and up or down have no such inexorable significance. The physical theory is not a new one, but a legacy from physicists of last century, notably, in Britain, Lord Kelvin.

Like other natural objects, our bodies would appear in the world block film, the later end of our lives being forward in time. Now, nobody considers as a vital matter the particular orientation of, say, a worm in *space;* but here is a case where direction is all important—the difference, for example, between a man growing taller and becoming shorter.

Eddington, throughout his discussion, seems to waver between his sense of loyalty to the commanding status of the physical world and the opposing idealistic view which discerns its dependence upon generating mental experiences and concepts, the withdrawal of which would eclipse into non-entity, not only what may be regarded as psychic additions, but every feature in its repertoire. While regarding the scientific four-dimensional world as having some standing objectivity, he, nevertheless, challenges anyone to exclude all rationality and significance from such world by denying the fundamental implication of the forward direction in time. "The physicist may say," he concedes *(The Nature of the Physical World,* p. 108), "that the *addendum* asked for relates to *significance,* and he has nothing to do with significance; he is only concerned that his calculations shall agree with observation. He cannot tell whether the phenomenon has the significance of a happening or an un-happening." Then he continues: "There is much to be said for excluding the whole field of significance from physics; it is a healthy reaction from mixing up with our calculations mystic conceptions that (officially) we know nothing about. I rather envy the pure physicist his impregnable position. But if he rules significance entirely outside his scope, *somebody* has the job of discovering whether the physical world of atoms, ether, and electrons has any significance whatever." (p. 109.) Following this sharp definition of the boundary of pure physics, a boundary which he hesitates to overstep, the idealistic view again obtrudes: "The scientific world is a shadow world, shadowing a world familiar to our consciousness. Just how much do we expect it to shadow? We do not expect it to shadow all that is in our minds, emotions, memory, etc." My own question here would be: "Just *why* should we be concerned whether or

not it ' shadows ' the intuitive process of ' becoming '? " And why should Eddington be so solicitous for the moral character of physical Nature, if that world is merely a world of shadows? Surely values can be taken care of in another, and more original, sphere. Is it really necessary to become involved in obscure theories about a one-way " texture " embodied in this world, or to connect this texture with a property like entropy? Further, why should we, like Eddington, arbitrarily postulate a locality in the brain, sensitive to entropy gradient, to provide an origin for a fact like becoming, particularly as the essential ascription of an ascending sense to this gradient *presupposes* a ready-furnished criterion of direction in time? Of course, the theory is admittedly speculative, for, although entropy must increase in the cosmos, it need not increase in any one locality—the brain; and I assume that there is no positive evidence to substantiate the speculation. Indeed, it would be a curious inversion if the intellect, the chief function of which is to elicit order from random presentations, were itself served by an organ of progressively disordered composition!

That science does not deal with an individual or personal world, but is concerned only with a common domain, is recognized by Eddington. He speaks of actual observers being superseded by an army of ubiquitous (hypothetical) watchers whose joint report is embodied in the conceptual common world (p. 227). To such an army, pervading time as well as space, the Universe is indifferent to " time's arrow ". In conceptual physical Nature there is no " formality of taking place ". Just as a chart is for the general guidance of mariners, not for recording the emotions or impressions of each voyager, so the block cosmic chart, if sustained in its purity, would seem to be unconcerned with our mode of intrusion into it.

Probably Eddington intends to be somewhat fanciful in his remarks about the pathology of reversed time. In experience time does not go either forward or backward; it simply *goes*. In a featureless medium a motor-car, with a norm of direction in itself, might be said to go backwards or forwards, but scarcely a cricket ball. Events might seem

to occur according to a reversed physical law, as when a cinema picture is screened backwards for comic effect, but the time of the observer continues simply to *go*. If we could imagine a super-cinema, which was not only a " talkie ", but a " touchie ", " tastie ", and " smellie " as well, to be similarly reversed—a remote, but not inconceivable situation—an observer might be said to traverse Nature backwards. It would involve simply an artificial method of transmitting the scene of the world to his senses, which would bear to the crude, unaided deliverance of Nature a relation not very dissimilar to that subsisting between the results of experiment with elaborate apparatus and naïve observation of the plain face of our environment.

I suggest that the occasion of Eddington's " arrow " is the conception of a constant identical personality, by which the successive cross sections, or film pictures, assume an integrated character altogether foreign to the generalized, impersonal viewpoints of the " ubiquitous watchers ", each of which might be replaced by a camera, gramophone, etc. The whole question, then, is bound up with personality, a certain feature of which Eddington would base upon a " texture " in the extensive world exemplified in brain process. He must recognize that only one feature of personality would participate in this arbitrary projection, for the attempt to found individual personality upon a cerebral characteristic is foredoomed to failure. It is impossible to imagine a physical characteristic of my brain which differentiates *my* feeling of, say, warmth from *yours*. I refer, not to any qualitative difference, but to the absolute numerical difference which ensures that you shall never receive the sensation due to the contact of a flame with my finger. No physical counterpart can be assigned for this complete separation. To science, so long as the appropriate physical reactions occur, it is a matter of absolute indifference whether the conscious experience should be yours or mine or a mixture of both, as is evident in the doctrine of behaviourism. Even if we could imagine two absolutely similar bodies and brains, it would be absurd to suppose that the personalities would on that account merge. Nor

can their failure to do so be attributed to a differing identity in the composing matter, for that would imply an investing of matter with some non-empirical quality. Moreover, the flux of the physical constituents revealed by modern research removes any colour of plausibility from a doctrine of permanent particular substance in matter.* A physical domain has no place for the manifest, but unprojected fact of individual personality, the true source from which the notion of identity takes its origin.

In speaking of the super-cinema picture in which an observer might be subjected to a reversed reproduction of normal experience, even with the accompanying feelings, we might have noticed one conspicuous feature of consciousness which would stubbornly resist the process of reversal, namely, volitional causation, the real essence of personal life, the inversion of which would be as absurd in conception as a square circle. It is here, not in passive reception, that external manipulation and external standards must fail. This carries a suggestion which leads to my third topic.

The Partial Indeterminism of Nature.—A point raised by Eddington, which is indeed sorely troubling the pioneers of science at the present time, is the apparent failure of the causal concept in the realm of quanta and sub-atomic physics. The difficulty may be summarized in the statement that the jump of electrons in connection with the reception and distribution of energy cannot be forecasted as a consequence of a specific cause. Statistical averages of these jumps are definite and amenable to casual law, but there is an indeterminism in detail. This, Eddington suggests, may turn out to mark the liberation of will from the shackles of compulsion, implied in a causally determinate world.

I must confess that this supposed liberation leaves me rather cold, because I doubt the efficacy of the assumption to affect the vitals of this ancient problem. In the past, theology has found much concern in the issue, but, from its point of view, the problem is left where it was, whether God be regarded as a Person or as the principle of order in the Universe. In both cases firm decree and organization

* See confirmation of this by Eddington in later work, "The Principles of Physical Science", 1939, p. 110.

are almost synonymous with determinism in some sense, but not necessarily in the sense that denies free will. If I may lay aside momentarily the severely dialectical tone which naturally characterizes an inquiry of this kind, I should say that it would seem rather unbecoming in those who, in the past, have denied any necessary antagonism between a world subject to law and the free responsible agency of the individual, to snatch at a straw of this kind, and thus admit a weakness in their former position. I think that the antinomy which this problem seems to present arises from the confusion between the conceptual world of Nature and the real self-existing world of individual experience. Free will simply exists as a fact of the most primitive and superlative order, and it can no more be an illusion than can the pain of toothache be illusory. But the fact of free will is one belonging to the individual world, not to conceptual Nature. I do not think we need feel any relief from the circumstance that certain electrons in our brains have elected to play a lone hand, but, with this chaotic principle admitted, we might well be uneasy for the future of science and perhaps, also, for the ultimate fate of the universe. Science, in the eyes of some people, has been allowed to assume the aspect of a Frankenstein monster, menacing its maker. But why should our trusty servant, really a departmental administrator, be supposed to represent the whole function of government. Free will is as plain as the proverbial pikestaff in experience, but bewildered men have looked for it, of course without avail, in the conceptual world of science, from which, since the days of fetishism, it has been deliberately excluded. On the one hand the advance into novelty is perpetual; on the physical side conservation is the basic law, which, imposed for our purposes upon conceptual Nature, resembles, as Bertrand Russell has said, the "great law that there are three feet in every yard!"

The value of free will, then, is settled in accordance with its manifest valid existence in our intimate experience. No doubt it may be disconcerting to think that our choice is foreknowable or foreknown, but it is difficult to see how that affects the intrinsic quality of the act, which stands

on its own merits. Perhaps we all have sufficient of the mystic in us to accept with reservation the conclusion which I showed to follow, even irrespective of Einstein, from the purely physical interpretation of Nature, namely, that there is no definitely assignable contemporaneousness of minds; but, if we do accept it, foreknowledge *in others* does not differ essentially from after-knowledge, which latter would clearly carry no detriment to free will. If the agent himself could know what he must do, certainly an impossible position would arise, but knowledge at best is fragmentary, and Nature, though it be theoretically *determinable,* will never be humanly *determined,* and least of all in the complexity of organic life. In the distinctions drawn in this discussion we touch again upon the central problem of becoming, and its correlate, personality. The word "must" implies compulsive volition, whereas in Nature there is, strictly speaking, no "must be", but only the simple future, "will be".

Before I close, please allow me to disclaim any fundamental objection to the departure of Eddington and others from the physical concept in its purified character of metrical extension, provided such a departure is clearly recognized and finally justified by results. It seems quite possible that a new scheme of knowledge should arise and embrace a larger and fuller scheme of concepts. My most important object has been to emphasize the barrier which separates the field of science from that of intimate actuality. Many acute thinkers, and notably, of late, Whitehead in *Process and Reality,* favour a scheme, reminiscent of Leibniz, in which all entities, including the elementary physical indefinables, derive their entire import from their place in the organism of the Whole. Practical science is scarcely in a condition to apply such a generalization, even if it were accepted, and so two classes of entities, the physical and the spiritual (using this latter term in a wide sense), might claim, at least tentatively, separate abstractive spheres. This claim, at all events, receives the support of Eddington, who says: "Correlating a real physical world to certain feelings of which we are conscious does not seem to differ in any essential respect from the sanction of correlating a

spiritual domain to another side of our personality." If an illustration already used in a different sense may be employed again, it might be said that we can play with our individual experience as with a pack of cards—play any game we choose; and a bridge player must not criticize, say, a euchre player because the latter is not using the whole pack, or obeying bridge rules, or *vice versa.* Eddington, if he had employed this figure, would have considered the scientist as analogous to the euchre player, for he says: " Within the whole domain of experience a *selected portion* is requisite for development by the scientific method."

There is, then, no limit to the number of possible conceptual worlds, and no single one can be assigned a pre-eminent character somewhat vaguely dubbed reality. Eventually a science may emerge which will require, not only " time's arrow ", but many non-physical elements, such as " rays of luck " (Eddington), and which will possibly unify in a convergent scheme the combined domain of our grosser and more refined satisfactions. Such a world, however, will not be physical in the hitherto accepted sense, and, whatever its character, it will, by its very constitution, continue to be a commonality, differing in essential respects from the pure deliverance of consciousness, which is the foundation rock from which all subsidiary structures must be hewn.

VII.

TIME AND THE CALENDAR*

THE problem of Time, in its character of change and passage, has in all ages puzzled and divided philosophers. Some, in despair, have called it an illusion. Surely anything real must have stability, and cannot be composed of moments the birth of which coincides with their flitting away. A contrary school has held that flux and change are themselves the only reality: the all-encompassing river of time has no banks. Some have blessed time personified as the great healer, while to others he has figured as the pitiless reaper and destroyer, although in fairness it should be admitted that what he sweeps away he has in the first instance brought to us.

This short talk can only skirt the subject, but I hope that it may suggest a few thoughts on matters usually too much taken for granted to excite enquiry. The mechanism of clocks (now capable of such perfection as to rival the great clock of the sky) and the setting of them for different zones on the earth to correspond with the on-coming daylight are in themselves large subjects on which I cannot now dwell. Perhaps radio, already such an important factor in time-keeping, may some day advance so far as to actuate automatically all our clocks and watches from a central time station. If so, it may impress on the dials, not only the hour, minute, and second, but also the year, month, date, and week day, thus giving a complete, accurate and direct reading of our position in time, as older clock-makers strove to do after the passing of water clocks, timed candles and the like. Many grandfather clocks attempt to show the date etc. yet, but radio would be less fallible and calendars would soon be at a discount. Our ordinary watches leave so much to our memories or to tabulated calendars which will not tell us the date if we have forgotten the week day. Clocks and calendars are really instruments of one time system, and *jointly* they perform many necessary services for mankind.

* Broadcast from 4YA Dunedin, 1933.

They tell us what point of the stream of time we occupy; they measure time, as for wages, statistics, science, etc.; they fix appointments, commemorative and religious occasions; they mark the process of Nature for the *daily* routine and *seasonal* operations; they provide a frame of reference for history and prediction.

Before proceeding to review, and perhaps criticise, the time measurements in common use, it will be well to raise a prior question: What are we measuring? What is it that clocks and calendars deal out to us in divisions? However philosophers may regard it, time is a constant companion with which we are all familiar, and it invites examination.

Space and time are often compared, and, indeed, our common phrases proclaim an analogy, as when we say " a space of time ". A thing can be near or distant either by the calendar or by the yard stick. On the alpine tracks of Europe direction posts tell the distance to a destination, not in miles or kilometres, but in hours, a more informative gauge for a tramper among the mountains. But time embraces more than space: it envelopes mental things as well as the outer world. A pain, a thought, a melody do not occupy space, but it is not possible to form a conception of anything which has not some duration. Modern science in its most precise researches has come to regard time and space as differing aspects of a single thing called space-time, but I cannot follow that rather abstract notion to-night. The time which each of us knows, the feeling of duration, is something quite different from space, and the movement of a clock is rather an index of it than the actual thing itself. I think we must give a verdict notwithstanding the poet, that in an important sense, things *are* what they seem; just what we *feel* time to be in our consciousness, *that* it truly *is:* description can make it no plainer. We can, however, consider whether clock time is a suitable gauge and measure of it. Is it so? I think everyone will agree that the pace of the clock varies prodigiously if compared with our inner feeling of duration. Even if we leave out of account the periods of sleep, through the great gaps of which the clock ticks merrily on, we all know how pleasantly occupied hours contract while minutes of boredom expand tenfold. (It is

a household by-word that a watched kettle never boils, and the calendar completely falsifies the length of the weeks for the child awaiting Christmas.) But a perfect *individual* time measure, even if ingenuity could construct a suitable clock, would not be of much use as a common guide. We can scarcely claim that a standard measure should have regard to our varying moods, any more than Tom Thumb or a giant could complain that the foot-rule took no heed of the length of their abnormal feet.

We must compromise by accepting something agreeable to the whole community in which we live, and it is a fortunate circumstance that clock time based upon mechanical law is so consistent with the *average* sense of duration in the human mind. Clocks, of course, must be set and regulated by a single standard of reference, just as a yard or metre bar laid up in London or Paris regulates measures of length. As a time check we are lucky enough to have a wonderfully constant regulator in Nature accessible the world over by reference to the skies. It is the daily rotation of the earth easily recorded at observatories. It is worthy of mention, however, that when scientists deal with the immensities of the Universe or with the minutest particles of matter, where motions of enormous velocity are encountered, our ordinary standards of time and length prove variable and inadequate, and mathematicians are very busy at the present time endeavouring to devise suitable gauges in which to cast the history and destiny of the Universe. Sir Arthur Eddington, interpreting the Einstein theory, assures us that if a man could only move rapidly enough, his lifetime, although not seeming longer to himself, might stretch through thousands of years of our calendar; and Sir James Jeans has declared that if the mechanical laws upon which our standard of time depends were strictly accurate, the whole universe would be shattered in an instant. This all sounds very extraordinary and alarming, but we have no need to worry about it. Here is an illustration. We are rightly content to trust the straight edge of a spirit level in setting a billiard table, a floor, or even a bowling green, although we know that an absolutely true level surface should, like a calm lake, curve a little with the surface of

the earth. So with our time-keeping: it is quite good for all ordinary, and most scientific, purposes, but it is not appropriate when we reach out towards the immensities and eternities.

Let us agree then that a well-made clock will deal us out even time; and we can proceed to consider the scales and divisions employed for short and long periods. The day-night period is our most important unit, but it is not always the same length of clock time, because the sun shifts in the sky somewhat irregularly. Our 24 hours represent the *average* day, and thus all comes even at the end of the year. This explains the common expression " mean time " which puzzles many people: it denotes merely average time, and it is usually a little different from sun time, as users of sundials know.

Intelligence cannot long have dawned upon humanity before some observation of time and season was translated from sheer instinct to conscious knowledge, and the natural cycles of the skies would first attract attention (although perhaps more primitive still for small measures of both length and time was the standard of the human body. This is still with us as in the foot, and in ancient writings is found the handbreadth, also for the smallest measure of time " the twinkling of an eye ".)

I cannot pause to speak of the methods used by the ancients to discern the exact periods of the year cycle, or the moon cycle (which of course is the origin of the month). They obtained wonderfully accurate results under the circumstances. It is worthy of note that the Maoris and other Polynesians use for seasonal reference star groups which were used by the Easterns in ancient times, and we may have here a clue as to a common origin. Astronomical time-keeping of a sort must have long preceded the earliest records: the evening and the morning were the first day, says the ancient scripture, and man in his turn could not possibly ignore these dramatic boundaries between day and night. In them we have the clue to the origin of our scale of 12 instead of 24 hours on the clock, although our a.m. and p.m. periods have now no regard for daylight and dark and we might well adopt the 24-hour clock as is often done

in Europe and America to avoid confusion, especially in time tables. Only habit causes us to think that it would be more cumbersome to say e.g. half past 21 than half past 11 even if we prefer such expressions to 21.30. In history, however, sunset and sunrise have often been used as zero hours. As an instance of the outstanding fact that Nature has overridden arithmetical or rational convenience in time reckoning, we find that the Greeks divided the night period and the day period *separately* into 12 hours each; thus with the long daylight in summer the day hour was stretched accordingly while the night hour contracted, an hour thus varying considerably in length. They even attempted to make clocks to show these erratic divisions. So it has been with the month, or moon period, and the year. A perfect Iliad of woes and confusion can be traced to the clashing attempts to reconcile these different cycles which Nature has not made to fit into a regular scale. It must be remembered that magic and divine influence used to be attributed to the heavenly bodies. Priests were charged with the duty of tallying the cycles, and sacrificial celebrations which have so largely influenced calendar-making were observed from remote antiquity. No doubt our custom of anniversaries, birthdays and other cyclic celebrations is a lineal descendant of astrological considerations. The date of Christmas is said to have been directly appropriated by the early Christians from the pagan feast celebrating the turning point of the sun at the December solstice. It was considered a fitting time to commemorate the birth of Christ.

Among calendar makers a great conflict has existed between the claims of the sun and the moon, the true year and the true month, about $365\frac{1}{4}$ days and $29\frac{1}{2}$ days respectively. To realise this difficulty consider a watch face. I suppose that in 99 or nearly 100 per cent. of cases the second hand will be found to disagree with the reading on the minute hand divisions, although if set together the hands will remain correct. But if faulty gearing can be imagined to have made the relative speeds of the second, minute, and hour hands a little in error, no matter how correctly the watch is set, the dial will before long present an ambiguous and sorry spectacle. This is what happens with the sky clock

of day, month, and year, which will not fit into each other in even cycles; if the moon cycle is observed the sun and seasons will soon fall out of step and vice versa. In regard to Easter this conflict is with us to the present time, but otherwise we now neglect the moon, the phases of which occur at continually varying dates in the month. But the moon was very important to ancient outdoor nomadic peoples. It would be the first obvious longer period clock in the heavens and the Mohammedan calendar still observes the lunar month and allows the seasons of the year to wander round the calendar. In fact the moon, although its period will not fit in with either the day or the year, has played a dominating part in many calendars, and has proved a source of confusion when attempts have been made to harmonise its period with the sun year. The week is rather a curiosity in chronology, and the only plausible explanations of it in astronomy are (1) that it arose from the four cardinal phases of the moon which occur approximately every seven days, new moon, first quarter, full moon, and last quarter, and (2) respect for the seven planets or moving heavenly bodies known of old after which the week days were named—Sun, Moon, Mars, Mercury, Venus, Jupiter, and Saturn. In our English calendar these names are changed from the Latin to correspond with the names of the Norse gods. The week is not, strictly speaking, a natural cycle, and weeks of 10, 8 and 5 days have been used by various peoples. A mystic significance has attached to the number 7, and the Jewish tradition associated it with the creation, thus imprinting on it a deep religious import which no acceptable calendar could now ignore. At the French Revolution an attempt was made to introduce a 10-day week, but the attempt failed. The week days being named, not numbered, and having no connection with the troublesome natural cycles have escaped much of the tampering with sequence which month dates and year designations have suffered by the frequent attempts to rectify faulty computations. It was a common practice long ago to insert days or even months into the calendar at odd times to bring seasons for agriculture etc. back to their proper place, and under this pretence rulers sometimes had changes made for their own purposes.

Our own present system is a lineal descendant of the Egyptian calendar which was kept comparatively scrupulously, extra days not being inserted capriciously. It had 12 months of 30 days and 5 days added annually. This made the year quarter of a day too short with the result that in the course of 1505 years the seasons made a complete round of the calendar, just as if our midsummer might shift from December to February in, say, seven or eight generations. Years were numbered reckoning from the commencement of the reign of monarchs.

The Roman calendar is the more immediate origin of our present scheme. It owes much to the Egyptians although its zero dated from the reputed foundation of the city, and in the earlier centuries 10 months made up the year, which commenced with March. Later the addition of January and February was made at the end of the year and they were afterwards moved to the beginning. The effect of this is still with us as September, October, November and December mean seventh, eighth, ninth and tenth, instead of ninth, tenth, eleventh and twelfth, which they now are. Until the time of Julius Cæsar, who, with the assistance of an astronomer named Sosigenes, made important reforms, the calendar was not efficiently kept and got out of step with the seasons. In the Julian calendar, as the reformed scheme was named, the leap year was instituted which gave sufficient accuracy to make the month of the year a true index of the season ever since. The Romans did not number the dates of the month consecutively as we do, but from three fixed dates within the month, the first of which was the Kalends from which our word calendar is derived, and of course they did not use the Christian era in numbering the years. Julius Cæsar changed the name of the month Quintilis (meaning fifth month) to July in his own honour, and Augustus followed suit by changing Sextilus to August. The months, which had been long and short alternately, were now tampered with (it is said) to gratify the vanity of Augustus, who, being unable to tolerate any suggestion of inferiority to his predecessor, gave his month 31 days like July and altered the sequence of the 30 and 31 days in the subsequent months, which, in turn, necessitated the shortening of February.

The Julian calendar assumed that the length of the year is 365¼ days which, though near the truth, is not quite accurate.

In 1582 an error of about nine days had accumulated and Pope Gregory ordered that these nine days should be omitted from the month of October in that year. He also decreed that leap year should not thereafter be observed in any century year the number of which was not divisible by 400. Thus 1900 was not a leap year, but 2000 will be. Under this system there will be no important error for thousands of years to come.

As the Christian religion advanced in Europe the seven-day week became important, with recurring Sundays and other holy days. Christmas fortunately involved no reference to the moon, but the Easter commemoration was closely connected with it. Here again came in the impossible attempt to harmonise the lunar month with the year and many conflicting computations had arisen which the Gregorian calendar reconciled. That populations are very conservative as regards calendar changes is strikingly illustrated in the fact that, despite its obvious advantages, the Gregorian reform has taken 341 years to spread over Europe, the last country to adopt it being Greece as recently as 1923. In Britain the 14th of September of 1752 was substituted for 2nd September. This was followed by the popular clamour "Give us back our lost days!" which seems ludicrous enough, but is intelligible for those with bills against them falling due on a certain date or with omitted birthdays, and so on. However the "old style" and the "new style" as they were called survived side by side for a time.

The use of the Christian era as a basis for numbering the years commenced with the sixth century, but the initial date of the year differed in different countries, some countries taking 25th December, others 1st March and 25th March. In England, not until 1753 was 1st January finally settled by Act of Parliament as the beginning of the year, although in Scotland that system prevailed from 1600.

Thus we have arrived at our present calendar, and the question naturally arises "Is it perfect yet?". We have got rid of the tyranny of the moon except in so far as we wish

to schedule its phases as we might any other recurring events such as the departure of mail steamers. We have done this with one important exception, the computing of Easter. The Jewish calendar was closely concerned with the moon and the rising of Christ is celebrated by the Church having regard to that calendar which has thus to be fitted on to our year. General consent in Christendom recognises the weekly celebration of this event on Sunday and that Easter Day should be a Sunday. This means that the true lunar cycle is observed only approximately, for the moon does not correspond with the week, while the annual cycle is very widely departed from. In making a compromise between the moon and the sun, both cycles are missed. Many people believe that it would be better to celebrate Easter as near as possible by the yearly cycle, that is in the same week each year, thus ridding ourselves completely from the influence of the old lunar calendar which has proved such a fertile source of confusion. An Act was passed by the British Parliament in 1928 providing the machinery for establishing a fixed Easter Day on the Sunday after the second Saturday in April, but it will not operate until a united sanction by ecclesiastical authority is secured, and the change has been confirmed. This does not seem very near at present, for the papal see has proclaimed that, while the change is not contrary to any religious principle, nevertheless only marked public advantage would warrant departure from tradition around which sacred sentiment has accumulated. Those who spend the Easter holidays in the open air may derive comfort from the fact that the present arrangement at least ensures moonlight nights, which the fixed date would not do.

I have intended this discussion to show how astronomical considerations have dominated our system of time measurements and how this is quite natural in view of their importance in determining seasonal recurrences, but that nevertheless it has proved impossible to fit all the movement cycles into one convenient system like an artificial length table. What should we think if a foot was sometimes 12 inches and at other times 11 or 10 inches

We must retain the day, the week, and the year, but strong movements for calendar reform advocate the better adjustment of the month now divorced from all connection with the moon. Perhaps the most favoured reform [1933] makes the year consist of 13 months of four weeks each with provision for an added day to be named year day and not numbered at all. In leap years two year days would be included. These year days would all be holidays and would serve for New Year celebrations. In this scheme we should have even periods for computing wages, etc., and calendars would not be required to inform us of the date or day of the week because Sundays would always be on the 1st, 8th, 15th and 22nd, and each week day would always have its own four dates which would become automatically remembered. Anniversaries such as birthdays would in some cases require readjustment, but for future time they would commemorate not only the year date but the week day. At present how many people know on what day of the week they were born? Perhaps among the long list of advantages claimed one of the most notable is the levelling out of statistics at present vitiated by the uneven months. This scheme, I know, is very unfavourably regarded by leading astronomers in England, but it has many strong advocates among business men and others, particularly in America. I have not time to weigh the pros and cons, but I hope I have said enough to-night to convince listeners that both the clock and the calendar as we know them, far from being heaven-given schemes, are very human institutions, and if improvements can be devised to make them serve human needs better we should not, when fully convinced, allow either inertia or sentiment to interpose an obstacle to reform.

VIII.

PHYSICAL AND MENTAL CRITERIA OF TIME*

I FEAR that my remarks will be found to run directly counter to Dr. A. N. Whitehead's almost impassioned protest against what he calls theories of the bifurcation of Nature. "Nature," to use his own words, "is nothing else than the deliverance of sense awareness." But this statement is discounted at once by what follows in the text: "Our whole task is to exhibit in one system the characters and inter-relations of all that is observed." Surely this "one *system*" is something different from the simple deliverance of sense-awareness. System can be supplied only by the constructive intellect. In justice to this great analytical thinker, however, it should be stated that he elaborates a doctrine of significance which seems cunningly to project out into Nature those intellectual factors which are necessary to make up that which is lacking in the purely sensuous, contorted and limited field which faces us at each instant. It would be interesting to expand here but I must not do so. My present object is to consider the character of time as it relates variously to Nature, the individual mind, and groups of minds, while Whitehead's system practically ignores the problems attaching to a multiplicity of percipient minds or subjects.

I shall say at once that the Nature, or public world, which I contrast with the inner or private world, is purely conceptual and does not either support or contradict any ontological speculations concerning it which may arise from other considerations. Eddington commenced his well-known 1927 Gifford lecture by contrasting sharply two worlds—that of common sense (tables, chairs, etc.) and that of scientific objects (electrons and the like). Striking as this contrast is, it is of less significance philosophically than the line of division which can be drawn between, on the one

* Read at Dunedin Philosophical Club, 11th May, 1934. See Author's Note No. 4, page 186.

hand, the series of fields in the actual form given in perception, whether by unaided sense or by instruments, and, on the other, the objective world which we construct in imagination and regard as existing independent of us and containing, as the case may be, trees, houses, books, etc., *or* electrons, protons, ether waves and the like. This division lumps together Eddington's two worlds as differing only in mode.

On the other side are our raw percepts—we may call them individual percepts—and they *are* what they *seem*, a penny really changes from a circle to an ellipse or straight line as it is turned edge on to our view. Contrary to the usage of common speech this series contains the real objects of experience, which actually we contort when we construct a common public world out of them. The habit of reference to, and deference to, the outer world is so ingrained by the impress of practical life that even some philosophers will still contend that when we look at a penny edge on we actually perceive it as round, but surely such a contention can only be supported by a strained definition of the word " perception ". No doubt close contacts occur between the fields of perception and the conceptual public world, and more so when that world is conceived after a primitive model rather than by scientific analysis. As we think of Nature the sensuous field before us mingles with images of other colourful scenes of land, sea and sky; but it is clear that conceptual Nature is at no time identical with the percepts of our private world, because we regard the former as continuing steadfast even when our eyes are averted. Moreover the objects of consciousness are not transferred to the outer world without instinctive or intellectual transformation, and often a wide gulf of difference arises in the process. We may know, for instance, that two trees within our view are about the same size according to measure, yet the one beside us is a labyrinth of branches and leaves while the distant one is but one small patch of colour. Space and time participate in this twofold aspect—which fact has often misled thinkers, but before I apply this thought, I should like to remark upon the oft-proved danger of attempting to build logical or epistemological structures without drastic

sifting to assure ourselves that we are not using concepts or terms belonging to diverse planes.

If we confuse objects as we perceive them with constructed metric physical objects we have taken the first step towards the mire of paradox and antinomy. My belief is that these latter are never the result of an inherent defect in reason. That is to say, reason if properly applied will not lead to contradictions. What happens is that we set reason to work, not on direct fields of experience, but upon a miscellany of fact and assumption. A smoothed-out world of law and order as a common domain is so desirable, indeed so necessary, for our daily life that loyalty and devotion to a conventional regime of concepts is irresistibly imposed upon us by instinct, self-expression and habit. Thus the critical faculty is often dulled so that people prefer to believe a conclusion arrived at by an elaborate chain of assumption, deduction and induction as against apprehension of an element of direct presentation, which is often surer and plainer than any one link of the chain, or the welding logic by which it is laboriously constructed. Hence paradoxes, which are invariably found to rest upon some secluded assumption to which we are so habituated that we accept it as primary fact. Zeno's paradoxes might be cited, but I shall take a simpler illustration in the use of the symbol 0 in arithmetical processes. From our infancy we are taught to believe that any number, say 4, multiplied by 0 equals 0. But take this equation:
$x \times 4 = 3 \times 4 \therefore x = 3$ (by cancelling of common factor); again $x \times 0 = 3 \times 0$ gives us $x = 3$ (by the same process).

But the last result is not necessarily true for x might just as well equal 4 or 5 or 1,000 and still satisfy the equation. Now is this a failure of rigorously correct mathematical or logical process? Not at all! The fault lies in regarding 0 or zero as a true number, which it is *not,* although it may be employed conveniently and usefully as such in many arithmetical processes. (See Note 4, p. 186.) The same fallacy arises with infinity, which nobody has ever experienced. For mathematical purposes we attribute certain characters to this idea and use it in conjunction with real quantities. When discrepancies arise from such procedure

logic is not to be arraigned. Infinitesimals, such as geometrical points, are in the same category: as in the case of the redoubtable Mrs. 'Arris, " there ain't no such person ". Whitehead has shown that a point is a product of our imagination based upon the notion of concentric spheres of diminishing radius, the series being projected as far as thought can go and then presumably handed over to the unknown. But if we wish to stick to concrete fact we must not go beyond the series of diminishing spheres. It may be doubted if any other source of confusion is more prolific than this failure to distinguish what we actually experience from the world which we call fact of Nature with dimensions and specifications all adapted to fit into a space frame or space-time continuum. Perhaps it may help to fix the idea in discussion if I tell a somewhat ridiculous story in illustration. At a cricket match a member of a travelling team, which had perhaps been too liberally entertained, was called to his innings but complained to the captain that he could see three bats and three balls. " Never mind, old man," sympathized the skipper, " hit the middle ball." Notwithstanding this advice down went the stumps immediately. " Why didn't you hit the middle ball? " demanded the captain. " Well, I did," explained the culprit, " but I hit it with the outside bat! " If in argument we try to hit a sensuous ball with a conceptual bat the result is sometimes disconcerting, and therefore I hope I have made clear what I mean by the inner and outer, the private and the public worlds.

Let me then emphasize the fact that space and time share with concrete objects the twofold dwelling place, for I am endeavouring to set the stage for the proper exhibition of the differing guises in which time appears according as it occupies the immediate field of perception on the one hand or the common domain of Nature on the other. The space and time which are presented to us in each perspective field certainly have properties different from those of the space and time so uniformly disposed throughout the ideal realm of Nature, although by reason of certain notions of homogeneity the transformations are somewhat elusive. One chunk of either space or time does not distinguish itself

from another very easily although in actual experience the chunks are discrete. We must bear in mind of course that some analogy must hold between inner and outer or we should never be led to equate them at all. Nevertheless it is obvious that the space occupied by the moon in a percept is radically different from the space assigned to it in Nature by astronomy; and so with other, less remote things. In the case of time we find an analogous difference. Our allowing a clock to convince us that a night spent in pain or suspense is of equal duration to one spent in peaceful sleep is powerful witness to the transfer of our allegiance from direct experience to the conventional domain of the common world, which has attained such prestige just because it is the medium of communication and the principle of order. When, with increasing age, we feel a year to be no longer than six months seemed in early life, it is surely only in the interests of social uniformity or science that we admit an unvarying period of revolution of the earth round the sun. What then is the nature of the bridge which connects the private and the public?—for bridge there undoubtedly is, else the common world would be entirely divorced from truth and fact. How is the relation established? First be it noted that the external world is pre-eminently a world of measurements. The essence of measurement is that the gauge used should be caused by successive shifts, if necessary, to cover the region to be measured, the number of applications being noted.

The gauge used must be judged constant. An example is the laying of a footrule by successive applications along a table. Now, in which world does the measuring occur? I think it certainly occurs in the private world, although the judgment of the constancy of the gauge concerns its status when projected into the external world. The measuring rod may, like any other object of perception, become foreshortened by perspective varying as much as an elastic band; but in our original judgment of constancy we have noted that its variations are similar to those of the generality of bodies deemed stable and rigid, which should qualify it to play the part of a norm in the orderly Nature. This judgment once made, we can thereafter identify the gauge by

its material individuality. The measuring must always take place in the private world, for it is in immediate perception that we observe the coincidences of the rule and the number of applications. Valid direct measurement implies further a judgment of contact—otherwise a halfpenny one inch in diameter when held in line with the moon would outmeasure it—but sometimes we dispense with direct contact and use instruments. Always, however, the data take the form of co-incidences in the private world. These are what Bergson called simultaneities and Eddington pointer readings. Consideration of the methods of space and time measurements brings home the fact that neither space nor time as experienced are really homogeneous. The space occupied by a book is not the same as empty space except by abstraction. It is in fact this discreteness that makes measurement possible. We cannot compare one chunk of abstract space with another. We select what we judge to be a rigid body and transport it as a gauge, and this rigid body acts as a substitute for a chunk of space although, be it said, not unambiguously. Unfortunately we cannot transport even a substitute for a chunk of time. We cannot pull out a piece of yesterday and superimpose it on to-day for comparison purposes. The recourse is to periodic recurrences which usually take the form of recurring movements such as the swing of a pendulum. Here again a judgment of uniformity comes in, and such judgment can claim no absolute sanction. The time lapses between the successive swings of a pendulum appeal to our consciousness as similar, also the intervals from noonday to noonday, and these judgments are found to agree subject to slight correction from computable conditions. Nevertheless there is reason to suppose that if a conscious being lived on an electron a pendulum might seem erratic. At all events there is nothing in Nature except simplicity of law to prevent anyone from using the wag of his pet dog's tail as the time unit if he feels disposed to do so. Even with our present constitution, just as perspective, etc., can affect the apparent size of the measuring rod, so attention, suspense, pain or sleep intervening may completely distort the apparent duration of hours, days or years. Nevertheless in both cases we have no

choice but to apply to the events of consciousness the standard scale deemed appropriate for the public world, viz. the clock.

It will be noticed then that in the selection of the standard gauge for both space and time we sacrifice to a considerable extent our intuitive judgment as to constancy—the apparent length of the measuring rod varies greatly with perspective and distance; and to a man in a deep sleep a long stretch of hours by clock measure can be of less apparent duration than a few minutes spent, say, in a dentist's chair. Is the external standard ultimately valid as opposed to a direct intuitive deliverance? Of course the standardization of the public world is a practical necessity: nothing other than a common measure of some sort can provide for cohesion of minds. A principle of this sort was recognized by a Babylonian monarch of old whose widespread dominions were giving him some concern, and who in search of a cohesive principle set up a golden image to which tributaries from the utmost bounds were to come and bow down in worship. Nebuchadnezzar found, however, that certain Hebrew exiles set paramount store by inner loyalties which proved inconsistent with this homage. And so while our regard and loyalties unceasingly attach to Nature, it happens now and again that there is set up in its realm by superstition or science, as the case may be, a golden image of some sort before which we are called upon to abase the dictates and deliverance of the clearest direct intuition. The "determinism versus free will" controversy furnishes a case in point. To revert to a former illustration, the inside ball is to be knocked clear over the boundary by the outside bat, and we wonder why the attempt fails! When one realizes the mode of origin of a public world or domain it must be fairly obvious that the character of the domain will vary as the efficiency of scientific work and method advances. Thus in the days of animism and fetishism all objects in Nature embodied living spirits, and even after these were exorcised classification of physical phenomena remained extremely crude. Even the common sense world has changed, while the world conceived by science has been quite transmogrified. This has come about by an ever-changing pro-

jection or transformation of the private world into public Nature, and we can readily assume that even greater changes may come. The very meaning of advance in science is the acquiring of a better index to the miscellanies of perception and their sequences, and this index, be it pictorial or mathematical, is Nature.

I am indebted to a recent book by Dean Inge for the information that Homeric Greek contained no word for generalized space. Probably the notion was the product of Eleatic and Platonic thought, for we certainly seem here to encounter the static rescued from the flux and also our old friend the general notion. The space of experience, like other objectives of perception is multiple—this space and that space—and the same remark applies to time. I should admit at once that recent thought has evolved theories opposed to the continuous infinite characters of space and time although the old orthodox ideas still prevail in the world of common sense. Let us examine briefly the implications for mind of changing forms and interpretations in the public world. It is well known that secondary qualities (so-called) have been banished by the mechanistic regime, and still more radically by the Relativists, but, on the other hand the public world has been invaded, notably by psychology which has introduced various entities and systems as affecting human minds and thereby human bodies —various forms of the ego, complexes, the unconscious, etc. The right of psychology here is unassailable for the only condition of occupancy in the public world is utility for its purposes. There is certainly no monopoly of entry for spatial, temporal or metric aspects—unless in worlds specially purged for a particular science. But with the advent of kaleidoscopically changing conceptual worlds one important function of a common domain seems threatened with neglect and collapse—I mean the function of collating communities of spirits or minds in a system which accords with the intuitive aspirations entertained as between man and his fellows. Hitherto the inner and the outer worlds have exhibited a certain community of character. If we symbolize my field of perceptions as I, Nature as N and the private world of any given fellow man as U, then

because I and N and U and N respectively are closely related, it follows the U and I feel a common bond even despite considerable displacement in space and time. Now, by the ruthless iconoclasm of new physical notions, these media of space and time have shared in the universal collapse of the old analysis of Nature. I wish to emphasize the effect on temporal relations. We used to think that we could distinguish our contemporaries, but Relativity tells us that what are contemporary and simultaneous events for us may from some other point of view, equally valid, be separated by centuries. Time is no longer one majestic stream wherein we may prick out events at definite points in the stream. In other words physics will not recognize absolute contemporaneousness at all. That attitude holds at all events as regards our bodies, but we are constrained to ask, is such doctrine acceptable as regards our minds? Matthew Arnold in a sad-toned lyric wrote about the isolation of spirits:

> In this sea of life enisled
> With echoing straits between us thrown
> Dotting the shoreless watery wild
> We mortal millions live alone.

But if we discover that, for instance, members of our household are in no more real sense our contemporaries than were the race of cave dwellers, now forgotten, we are at least startled. It matters little though present theory places some merciful limitations to the disruption of the order of common sense—we are still allowed certain limited realms of absolute past and absolute future. What concerns us is that the principle of interference by physics with the intuitive framework of social relations may subject the whole spiritual realm to an anarchy of ideas, disturbed anew, and to any extent, by fresh alignments of ever-varying concepts and laws. Physicists do not as a rule now claim absolute truth for any laws in a system: the work of Henri Poincaré, the great French mathematical philosopher, supported by Einstein and others has changed all that. The Ptolemaic geocentric theory of the solar system may in itself become valid if the accompanying system of laws is kept appropriate. Recent physical constructs are entirely dependent upon the

hypothesis that no signal can travel faster than light, and nobody can say that such hypothesis is final. Again, though a system of physics which reverts to an infinite velocity of light is entirely out of the practical purview just now, who knows? The undulatory theory of light and the doctrine of the ether seemed at one stage unassailably entrenched, but both have now given ground to rival hypotheses. Until the year 1675 if people had possessed acute enough vision to scrutinize the lives of beings inhabiting a remote world in a spiral nebula, the belief would have been universal that these distant fellow-beings were contemporaries of the beholders, because nobody doubted that events were actually proceeding at the moment of the visual perception of their happening. In the year named a Danish astronomer noticed a delay in occurrence of eclipses of Jupiter's satellites which was inconsistent with Newton's laws. So was born the theory that light travels with finite velocity. From this it follows that the beings seen in the nebula were not there at all, but probably had decayed into dust before our historic time commenced. May we likewise then be mocked when we imagine ourselves to be in the actual presence of the living activities and feelings of our intimate friends. If we attempt to rationalize our mutual knowledge of each other we find we can invoke only the public world as a medium of intercourse. This public world is subject to the modifications found convenient by advancing science, which may at any time pronounce our customary interpretations as illusion. I have instanced the case of the nebula dwellers and people of the 17th century, and it may be thought that as far as concerns neighbouring fellow citizens no such risk of illusionment can attach. Well, perhaps not; but what if, for example, a theory of a negative velocity of light be applied. That is to say if it be maintained that we see things before they actually happen and that the nerve transmission of touch and hearing to consciousness be likewise affected, and in a prodigious degree. What would then become of our social ideas: the faces and voices of our friends would be little better than talkie picture shows. So it would seem, but the observational basis on which transmission theories rest would doubtless preclude these fanciful situations. The

common test is that of response or echo—a ray of light for example is reflected to its origin and the lag noted. But is the touchstone of response necessarily final and valid? One more fantastic theory only is required to account for the fact that I receive immediate answer to a question addressed to someone in the vicinity whereas the reply is delayed in some measure if my interlocutor is in the far distance. We might postulate that people's responsive powers varied in ratio with their proximity or remoteness. This thought would require elaboration which I shall not attempt. The point is that the field is now open for any amount of manipulation, and the character of physical Nature is no longer stable, if it be not indeed as clay in the hands of the potter. Must we allow the minds and persons of our fellows to be bandied about from epoch to epoch according to the requirements of abstruse formulae? Strictly speaking, no doubt, the recognition of fellow minds could not ever be regarded as scientifically deduced: it is an act of faith, only intelligible by reference to our own past. John Locke, for one, held that a man would be actually a new person if memory concerning former existence failed. My own belief is that we have here the actual basis of our notion of other persons, although I should not accept Locke's view as ontologically adequate. The actual truth is mystical and we cannot embody it along with empirical ideas in a logical scheme. We attempt such a thing at our peril. Herein seems to reside the modicum of truth in solipsism, which although preposterous as an ultimate philosophy, presents a point of outset in thought which was commended by such a sane thinker as was the late Professor Wildon Carr as the beginning of philosophical wisdom—not the end, be it noted. When Laplace told Napoleon that his science had no longer need of the God hypothesis he might have added that in strict truth he could dispense also with the fellow man hypothesis by regarding them as automata. Both positions are tenable from the standpoint of physics, the object of which is to construct an external schema which will serve as an oracle in assisting us to forecast the actual and potential future of a private world. If by some intuition or perfect instinct we could perceive these things without the aid of science, scien-

tific theory would be just so much clumsy lumber. We should have attained the ideal set by Whitehead of directly relating the sensible, with the sensible, that is one part of our perceptive world with another, without any intermediary construct. In that case all the changing concepts of science—velocities, entities, etc., would be in danger of going by the board and taking with them the implied dictation as to our time relation with our fellows.

To apply the touchstone put forward in this paper, are we to judge from our own private world (as all people were ready to do prior to the year 1675) that when we see a face smiling, no matter at what distance a happy thought is passing in a mind at that very instant, or, on the other hand, are we to suspend all judgment as to present, past or future until science has delivered its final dictum? This thought, although perhaps not a very profitable one in itself, does carry the suggestion that the long cherished assumption which immersed minds in the measurable stream of time may be purely imaginary and may not admit of any assignable meaning. For if the bridge of the physical world is removed, or has become so wobbly that it is no longer trustworthy, how are we to pass from one mind to another? In the midst of an unbounded space it would be unmeaning to assign position to a single particle—or to any number of particles without the aid of some intermediary instrument. Similarly with minds—remove the medium of communication, or hopelessly vitiate it, and it would seem that *ipso facto* you poise individual worlds in immeasurable isolation. Epoch, era, become empty terms, and the solace of imagining that some hideous thing is over and done with is based upon a subjective viewpoint or is a complete illusion. There is no real community or history of minds or spirits, and joint progress is a fiction.

It is true that we are left with our private world in which, despite relativity, simultaneity, past and future are absolute or at all events real, although Bergson's philosophy launches an attack upon all quantitive or positional implications therein. He would collect mental time disposition into a purely qualitative interpenetrating nucleus, a very difficult conception with metaphysical rather than empirical

foundation. In my view the private world stands in its native character unassailable by theory.

Eddington has shown concern that the abstractiveness of the modern physical world has robbed it of the dynamic factor which is active life with a uni-directional forward flow, but I think his lament is unnecessary, because that is an affair of the private world, which he seems to regard (erroneously, I submit) as identified with the changing formulae or imagery of physics.

If anyone should imagine that I have exaggerated the significance of the change in the scientific outlook I am willing to admit that I have thrown the high lights on to the fringe of the picture; but philosophy is naturally exploratory and concerned with those elements which must condition expanded application of the principles adopted. That the actual thoughts of men of science are already driving home these principles, reckless of established prejudice, will probably be admitted by anyone who has read in the January number of the journal *Philosophy* an article by Professor E. A. Milne, a Cambridge mathematician and cosmologist of the first rank whose contributions to the deliberations of the Royal Astronomical Society for some years past have been outstanding. He alludes to the fact that owing to the abolition of absolute time evolution has lost its meaning, but concerns himself mainly with devising a character for a universe which will fit modern theory particularly as to conflicting elements of time. The famous second law of thermodynamics which implies the doom of the universe by the running down of effective energy is itself nugatory unless a specification be given of the particular time system which is to determine past and future. Many cosmologists now regard the universe as expanding in such sort that the assignment of a commencement to the expansive process seems to point to original creation. Milne embodies this conception, and his universe comes out as one in which the leading thought is a diverse time system for each constituent world, so that each, while growing old and running down in energy level, may look back to a real creation epoch. Not only that, however, but the inhabitants of any ageing world will always be able to envisage within

the Universe other equally real worlds in whose time system creation is an affair of yesterday. This reconciles creation, degradation of energy and eternal duration, but I should not like to sponsor all the logic of the construction.

Let me summarize the main thoughts of this essay.

Necessity and ingrained habit cause thought to move in a common world which is orderly and well fitted into the block of space and time. That this is not identical with the private world of direct perception is clear when, for example, the distortions of perspective are considered. Strictly speaking, however, the distortion is the other way about, for the native source of evidence is in the world we know in conscious experience. If the private world be confused with public Nature paradoxes arise. Time, like material objects, suffers distortion when transplanted from experience into Nature, as is manifest when we compare the duration of a clock hour of suspense with a clock hour of pleasant activity. If Nature be regarded with the naïvety of common sense the discrepancy is not too violent to be tolerable, but modern scientific interpretations of Nature have robbed it of a stable time standard and substituted a variable or purely symbolic time in which past, present and future have no absolute significance. Within an individual mind, or private world, however, a real meaning always attaches to simultaneity, and to past, present and future. Also an instinctive urge impels us to include our fellows in such a system, although the medium of communication and emplacement, physical Nature, does not now offer a stable framework. Physics, of course, is not concerned with communities of minds. When Laplace told Napoleon that his science had no need of the God hypothesis he might have added truthfully that it had no need of the fellow-man hypothesis, the freewill hypothesis, the beauty hypothesis, the goodness hypothesis, or the absolute truth hypothesis—and now could be added the time hypothesis as formerly conceived. That some, at least, of these concepts are, nevertheless, demanded by the mystic urge nobody will deny; and it is doubtful if we could ever agree that there is no real meaning, for example, in the belief that past suffering of a friend is over and done with.

IX.

NATURE AND PRECISION*

PRECISION has usually commended itself as a virtue. At infant school we were told to toe the line; but this first inculcation of precise order might, had we observed more closely, have revealed the limitation that toes in line probably meant heels somewhat out of alignment. So in modern physics one encounters the Heisenberg principle that an attempt to locate a moving particle with complete accuracy inevitably renders indefinite the assignment of its momentum. The controversy over causality which has flared up in recent science is really only one phase of the more general question of precision or definiteness in Nature—an unchallenged assumption formerly underlying theory as an unconscious postulate. Of course an important difference always holds between loose and rigorous thinking or description; but do we in seeking absolute accuracy pursue a chimera? Further, is there a politic limit to such a search —a region of maximum lucidity beyond, as well as before, which the mists of confusion gather or impotence supervenes? This topic has been much to the fore in recent philosophical discussions—as witness, for example, articles in the American journal *Philosophy of Science* headed "Vagueness and Logic", "Science and Vagueness", etc. The import of the subject in science was emphasized in my mind as I listened to the presidential address in the Physics section of the British Association for the Advancement of Science, as delivered by Dr. Darwin at Cambridge in 1938, in which he contended that future advances in physics lie along the path of approximation and probability concepts and methods.

Heisenberg's Principle of Uncertainty, just referred to, may seem to be a small part in physics—an exception remarkable for its singularity—, but an exception is apt to be important, not chiefly by its subject-matter, but because

* Read at Dunedin Philosophical Club in 1939. See Author's Note No. 5, page 186.

it may be symptomatic of radical misconception in a whole theory. Such was the case with the erratic element in the orbit of the planet Mercury shown by Einstein to import a complete change in the scientific conception of gravity. We may reasonably inquire, then, if ultra-precision is the real key to the scheme of Nature. Jules Verne's hero of accuracy, Phileas Fogg, dismissed his valet for bringing shaving water of a temperature differing by four degrees from that stipulated, but presumably even this paragon would tolerate a variation of one degree or a fraction of one! Shakespeare's *Macbeth* reflected on the anomaly that

> Hounds, greyhounds, mongrels, spaniels, curs,
> Sloughs, water-rugs, and demi-wolves are cleped
> All by the name of dogs.

General terms always imply some margin of looseness in application, and so Plato could find satisfaction only in the archetypal ideas laid up in heaven. The actual empirical investigations of science seem inconsistent with a rigidity excluding all ambiguities. Nature must be approached with pincers not already closed, but with jaws somewhat open for the next bite. Mr. A. C. Benjamin of the University of Chicago has said: "Vague ideas are part and parcel of science, and any theory of meaning which denies them is not a theory of science." *(Philosophy of Science,* October, 1939.)

Mankind, in the advance from a primitive condition, has varied in his confidence regarding the possibility of framing Nature in precise lines. First the idea of order was confined to a narrow application in the immediate and familiar environment: within the walls of the city a measure of control could be based upon a fairly certain and dependable behaviour of the materials upon which daily life and industry rested (although even there occult intrusions seemed to damp any great confidence in rigid law); but out in the wilderness, mountains and distant places, confusion and chaos reigned supreme. To extrapolate by a rigorous line of thought from the known to the unknown was altogether too precarious. Later a little more boldness was exhibited by thinkers; e.g. a small triangle was drawn, and its properties, when established by close study, were

confidently attributed to all similar triangles in the Universe, however large or small. Archimedes undertook to move the world if provided with a fulcrum and a sufficiently long lever. But even that philosopher did not dare to say that he, and every other man, actually did move the world (albeit by ever so small a fraction) every time he stepped along the road. Outside the region of immediate sensible discrimination it seemed precarious, or at least inappropriate to proceed. This attitude remained a background down to modern times. The idea that properties based upon refinements of observations within small compass could be extrapolated to amazingly intricate machines, or to vast and remote regions, as in astronomy, was long in being grasped and exploited. Then, when at last this notion was appropriated and used with marvellous success, confidence in it was unexpectedly shattered by a new discovery. In regions extremely remote from sensory observation, on the sides of both minuteness and immensity, the well established, clear-cut laws and ideas completely broke down. A single entity appeared capable of putting on diverse natures at random, and the fabric of time and space themselves seemed to be subverted and ruptured. I cannot attempt to elaborate the manner of this: the fact is now well known. One might ask in trepidation and alarm if we have returned to the primitive outlook. The walls of our law-controlled city have been far expanded; but do we still look outward to the chaotic jungle or the clouded mountain tops where inscrutable deities wield their capricious thunderbolts?

Another suggestive fact is that our ultimate standards of exactness are now seen to assume a rather ambiguous character. The solid reference bars, preserved with meticulous care to sustain the uniformity of the yard and metre, are not merely dancing atoms, but more correctly oceans of tumbling waves. Again, the stars by which we check our time are really hurtling through space at imperfectly known velocities as they are played upon by a multitude of unassessable forces. Their apparent stability or regularity is an optical illusion resulting from their immense distance from us—just as a far-away ship at sea looks stationary.

The everyday conception of the world regards it as a set field of objects which may be investigated with any degree of precision we may choose. Although we may fail in arriving at the absolute and unsurpassable truth about the objects, that is a weakness of thought or method, leaving the fixed structure and elements of the world still standing in unimpeachable integrity, and offering the prize of final success to the intellect active and acute enough to penetrate the secret recesses. Closer consideration and experience may show that, whatever its metaphysical or ultimate status, the manifold of objects as we know it is more like the composite shadow of our own minds, containing features so elusive that in the very act of our pointing their place they flit away. We are left to ponder whether in this flux the notion of precision can find any exemplification whatever. Certainly there is a difficulty in carrying forward a past (and therefore foreign) standard into a context of ever-welling novelty; and yet precision must mean the coming up to some established standard in its full import. We encounter here the age-long antithesis between the one and the many. Early in our line of culture the Greeks discerned something unsatisfactory in the vague and moving manifold of Nature—something that could not be made to correspond with the static serenity of the ideas and terms by which the manifold was scanned and characterized. Widely diverse things were subsumed under a common term. The valorous soldier with his blood-stained sword, and the philanthropist feeding a hungry child, were alike called virtuous. Where in such confusion could rigorous thought or philosophy find a resting place?

A refuge from such considerations as the foregoing was found by the Greeks in geometry, devised earlier by the Egyptians for the apportioning of land, but now seized on as a steadfast frame in which, peradventure, the ungoverned turmoil of the changing scene might yield up to view some modicum of rationality and reality. The distillation of the static and enduring, as opposed to the churnings of the phenomenal world, formed the basis of the classical tradition which the medieval scholastic philosophers inherited and transmitted to us. Clear-cut incorruptible ideas, and formal

Aristotelian logic admitting no loophole of doubt or uncertainty, were diligently sought; and anything falling short in these respects was condemned.

The extent and depth of the pervasion of Greek thought in the whole modern outlook, including science, is difficult to assess; but it must be remembered that the Greeks themselves were by no means unanimous regarding the attitude which has become dominant in tradition. Some of the schools dissented, and were indeed contemptuous of the philosophers of the One, the stable and the precise, maintaining on the contrary the supremacy of the many, the flux, and the contingent; and this antithesis has asserted itself also in European culture, especially in later times. Doubtless in practice hosts of people have always ignored the preaching of philosophers who exalted the rigours of reason and abstract entities against the swaying vicissitudes in which common humanity is apt to find the spice of life; but for long few were found to embody this attitude in philosophical terms.

A new phase arose with the well-known story of the rise of inductive methods and the gradual discrediting of the ideal and "a priori"—at least as far as these were implied in the investigation of Nature. Nevertheless, a long period has ensued during which a modus of give and take has been current, as between the empiricist and the formalist. The empiricist could not disregard deductive methods, nor could the classical logicians challenge the new induction as a mode of inquiry and an eliciter of truth (in some sense). Of course induction is a shocking case of imprecision. No method of induction is infallible save that of "simple enumeration", which can scarcely be called induction proper: and up to the present time nobody can give a satisfactory reason why induction should be valid at all. While it is probably true that intellect could scarcely function normally in a world where inductive inference proved usually invalid, intellect can, and in fact does, function normally in our world where induction is at best precarious. Here was a tremendous hurdle for the apostles of mathematical and logical rigour. They thought they had possession of the keys of the unseen world, on which the stream of phenomenal Nature must

ultimately depend. Further, they thought that a sufficiently searching logical analysis could reveal more and more of Nature itself. Hegel inherited the essence of this attitude, and, despite the rising tide of inductive science in his time, he virtually construed the material universe as congealed logic, and ventured to predict that no new planet would be discovered because the then known number was a perfect one!

I am taking up some time with these fragmentary historical remarks, not merely for their philosophical interest, but because they lead on to the matter of the recent change in the outlook of science, which is merely a further step towards breaking down the sacrosanctity of preconceived theory as applicable to the empirical phenomena of Nature. Dr. Darwin, in the lecture already referred to, said: " The history of the development of physics in the first quarter of the twentieth century will rank as one of the greatest in the advancement of knowledge, but it will also rank as one of the most curious in the history of thought."

We are apt to think of the break with Aristotelian scholasticism as brought about rather suddenly by such men as Francis Bacon and Galileo, but in fact there were many actions and reactions. Scientific thought and method, not being themselves very securely based on reason, have had need of the more stable and precise background of classical " apriorism ", which need, although the satisfying of it is not unattended with dangers, is really imperative. Some metaphysical presuppositions and " a priori " logical method are inseparable from any intellectual activity, scientific or other. To refer to Dr. Darwin again, he quotes Professor Ehrenfest of Copenhagen as saying: " To believe that one can make physical theories without unobservable quantities —that is one of the diseases of childhood! " The truth is that metaphysical " a priori " ideas and methods are apt to be, and have in fact been, very much intertwined with empirical procedure in the investigation of physical Nature. Two notable instances of this are presented by geometry and causal action. We may trace the idea of precision in the case of geometry as applied to science. Geometry was a trump card in classical times, and its rigour and precision

have given it a high place in intellectual activities down to the present day, although the dissecting knife of criticism has lately shorn it of its former halo. Here was something that would admit of no fuzziness but rested upon clear-cut, exact relations among figures compelling absolute and unqualified assent. There were no reservations in the mind, nor could there be (so it seemed) in the world of space. Hold fast to this impregnable rock which no superior ingenuity can ever shake or render ambiguous in its outlines! Even science with its eye on the changing world could not resist the appropriation of this unsullied weapon.

The heretic appeared in no less a person than Newton himself, and his brilliant contemporary, Leibniz. Certain problems seemed exceedingly refractory to orthodox geometry, but proved capable of solution by a new method named by Newton the method of fluxions, but later known as the infinitesimal calculus. Essentially it implies that a formula which approaches a quantity nearer than any positively assignable error or defect does actually designate that quantity. The sum of an infinite series, $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} +$ etc., although in any positive expression always differing from unity by the last-named fraction in the series, is nevertheless equal to unity. Similarly the number nine repeated without limit after a decimal point equals one. In the long run the intervening remainder becomes an "infinitesimal", which means in effect that it vanishes. This principle has become a very useful one in mathematics, but it did not escape unchallenged by the apostles of rigour. While such objections have been overridden, we can nevertheless understand the attitude of the conservative philosophers. They regarded themselves not merely as the exponents of a practical art, but as the custodians of the eternal verities which lay behind, and superior to, the world of appearance. If even minutest errors were allowed to pass the censor the fountain of truth was in danger of pollution at its source. We have something analogous to-day in the controversy over causality and indeterminacy. The conservative and other objectors to the calculus fell into the discard, and it is now generally held that an infinitely near approximation is indistinguishable from precision, at least in so far as that notion has any

application to Nature. One might even go further and claim that exactness derives a somewhat negative meaning from the actual circumstances of its assignment, just as one cannot conceive infinity positively, but only as something to which no end can be assigned. Congruence of a measuring rod can at best be determined only within a margin of error, and so " absolute " congruence transcends possible experience.

In recent times orthodox geometry has undergone a change of role. Formerly it was the prosecutor, now it has become the defendant. Some hint of its ambiguous character was foreshadowed by Kant's schematism, in which space figured in a dual capacity, as at once ideal and real. It bridged the gap between the worlds of thought and objective Nature. But can space be allowed thus to masquerade under two diverse flags? Newtonian mechanics accepted the space of orthodox geometry as basic and indefeasible, but this tenet has been challenged by modern mathematics. Some at least of Euclid's axioms have been shown to be merely postulates, which are to be accepted or used only so far as they are found empirically to fit into Nature—other axioms and postulates being capable of substitution to produce new geometries which perhaps provide a better frame for many facts of experience, and so supersede Euclid in that context. The great practical application of this principle was reserved for Einstein, who accepted the criticism that the boasted " a priori ", unimpeachable status of geometry, was unfounded. Certainly it contained an ingredient of pure logic sharing the prerogative of reason itself; but it also contained an empirical element which was involved in all the vicissitudes and questionings of inductive science and could support its vogue only on pragmatic grounds.

Apart from the fact that I am not competent to trace the intricacies of the new geometries, it is undesirable that this brief attempt to record the evolution, and assess the philosophical significance, of the new attitude should be unduly encumbered by any attempt to do so. What I wish to emphasize is that this traditional and predominant engine

of precision (orthodox geometry) has proved itself incompetent to frame completely the elusive manifold of Nature in hard lines of precision. We are all familiar with a point as that which has no parts and no magnitude; and we can realize how difficult it is to find such a thing in the objective world. Precision it may have, but, must we say, non-existence? Lines and superficies share the same fate. Dr. A. N. Whitehead has made a notable attempt to relieve geometry of the problem raised by points, lines, etc., in their noncubic phases as defined by Euclid. For a point Whitehead proposes a series of shells like the skins of an onion, the diminishing series to stand instead of the point. In a similar manner lines, surfaces, and even instants of time are dealt with; and by thus taking conformations of positive figures instead of null abstractions he hoped, as he says, to relate the sensible with the sensible. No doubt this is a step towards realism, and it may provide an easement for some difficulties. Nevertheless, it may aptly be asked if perfect figures or boundaries can be found in Nature any more than points themselves.

It must be remembered that at least a much espoused view of the physical world regards it as being constituted and conditioned (within the limits of possible experience) by our powers of measurement, or assessment by means of the senses (aided or unaided). If something is utterly beyond the reach of such senses it can scarcely be said to inhabit the world as we know it; and it is certain that the senses, even with the greatest conceivable aid from instruments, have some margin of vagueness. All the uncertainties and difficulties of exploration thus become real obstacles to the establishment of precise qualities or relations. Moreover, since the mathematician Minkowski, time has become inextricably interwoven with space, and it is doubtful if the ideal cross-section constituting simultaneity can be realized objectively. The world is flux permitting of no momentary pauses in which a perfect static figure can be described. We reflect again on the paradoxes of Zeno. A body moving from one place to another must traverse all the intermediate positions; yet if the body is in motion it cannot occupy a position for a finite time—that is, it cannot occupy it at all.

This and other similar paradoxes have puzzled philosophers for two milleniums, and only in recent times has it been realized that the assignment of a static position to a moving body is not justifiable, and is responsible for the resulting paradox. The transfer of a precise ideal notion from the mind to Nature is the cause of the trouble. In other words, inappropriate first principles are applied. By using a different scheme of ideas, Frege and others have resolved the problem of motion without paradox. Yet I think it would be found that even these new principles, if applied without reservation, could lead to other paradoxes. Nature possesses a free and fuzzy character that will not be framed on exact lineaments.

A leading implication of the thoughts I am advancing is that precision, in so far as it has actual application at all, finds its proper domain in the intellect, and not in Nature. It would appear that man was at first hesitant to apply the perfection of his ideas to the outer world, then became bold and pushed them out towards the infinities with full confidence until the check of recent discovery revealed phenomena which will not take the yoke so carefully prepared for them. Lord Kelvin spoke rather contemptuously of those who expressed diffidence in approaching alleged inconceivable numbers and magnitudes: "I leave inconceivability to the metaphysician," he declared, and then went on to speak of the "perfectly conceivable" multi-billions of the immensities. He had faith that his mechanical models could function in any amplification or diminution of scale. However, astronomy on the one hand, and sub-atomic physics on the other, have found sadly that Nature in these far-off phases will not fit the old harness. Slight and unnoticed departures from precision in ordinary magnitudes have expanded into wide divergencies when the remoter regions are explored; and so new weapons of thought must be forged. Nor is it to be supposed that these latter will prove competent to encage the whole universe in the meshes of precise thought. Such things as wave-atoms are well known to hold the stage of present-day science, even if they are difficult to align with our orthodox and classical ideas.

It might be in order here to pass from shape and quantity to a consideration of number, which of all things might seem the type of unassailable precision; and one must admit that very difficult problems arise here. Is not Nature at least positive and clear-cut where numerical character is concerned? Two inches, two acres, two gallons, could never be isolated exactly; but surely two bricks are two indubitably and without any divergence however minute from just two. Nevertheless a difficulty arises here not very dissimilar from that affecting general terms, which cover up individual differences under a pseudo-uniformity. Number strictly should imply a repetition of absolutely similar entities; but Nature has no duplicates. Leibniz found his monads to have irreducible individuality, and a materialistic concept of similarity which ignores difference in time and space setting is out of keeping with modern physics. We may count " one, two, three ", but, to whatever objects we apply the successive words, the objective series is not numerical purely and simply, but is polluted by irrelevant variations. Pure number is ideal, but it has been vitally important in the method and history of science. Pythagoras initiated a great cult in acclaiming number as the essence of all things, and modern physics is close on his heels. Pure number is sought in atomic theories, but is elusive owing to physical vagaries, although atomicity, by which number is made to transcend quality, seems to promise the route to success. Two cities may be somewhat alike, two houses more so, and two bricks more amenable still to a single category. Push the analysis further and atoms are arrived at, by which it would appear that the world is being reduced to a uniformity. Character in the unit is disappearing. Atomic chemistry, however, still fell short of pure number, because different sorts of atoms had to be recognized. With the breaking up of the atom another step was taken towards entities less and less capable of characterization by structure or property, but the total elimination of this has not yet been achieved. When it is brought about it would seem as if the Pythagorean world were approaching achievement. Meantime we must say that number itself cannot be transferred without some ambiguity from mind to Nature, or be found in Nature per se—at least

in any Nature as yet envisaged by science. Yet there seems to be a perpetual seeking for unalloyed number. As an intermediary between Nature and intellect it seems to offer more promise than Kant's space and time which have now been vitiated from their pristine purity by relativity theory. Quanta of energy mark another advance towards atomicity in Nature—that is characterless number. As yet quanta, like the other fundamental particles, retain some differentiation and character—at least in their paths, and therefore in space-time specification; and it is difficult to suppose that complete similarity can ever be attained, with the consequent enthronement of pure number in Nature.

Some departure from strict logic in assessing Nature was recognized long ago, notably in the rise of inductive method as against the rationalism of the middle ages, but also in the logic of probability worked out by nineteenth century mathematicians. An attitude fundamentally different however obtains to-day. In former times induction and probability were considered as more or less imperfect methods of *ascertaining* truth: the *fact* itself lay hidden in serene security, whether successfully brought to light (as was hoped) or not. Nowadays it is not a question merely of seeking to come by chance on a hidden treasure of truth to which no clear pathway leads, but the objective fact itself is not definite, and cannot in principle be absolutely defined. It is like exploring the South Pole; in old time its position was obscure by reason of the unsurmounted difficulties of the ice; but even after it is visited and subjected to most rigorous survey it will still be vague, because it is not in fact a definite point at all—wandering, as it does, over an area not quite definable.

Dr. Darwin's main argument was designed to show that ideal, rigorous thinking must give place to a wider mode of approach which does not despise induction, approximations, and probabilities. A notable contrast holds, he adds, between the way we think about things and the way we think we ought to think about them. Actually, we rarely conform to the ideals of Aristotelian logic, but lean upon arguments having no accurate axiomatic basis, which nevertheless

compel belief because of some large accumulation of favourable evidence. I may venture as an illustration of my own the scooping of fish out of the water by means of a net: the holes of the net, far from being a weakness, are a source of strength as compared with a totally impermeable fabric. Yet that is not the point of the new probability: indeed it serves to emphasize an essential and easily missed distinction between the older outlook and the position of probability in the new physics. It is not that we use an imperfect weapon in order to succeed the better in capturing an elusive quarry, but that the quarry itself when in hand will not admit of precise and exclusive definition—any more than the end of the rainbow will admit of precise location. Darwin stated the application of these principles to causality as follows: " It is now easy to see that there was nothing wrong with the old inference that if I know all about the present I can forecast the future exactly; the trouble was the impossibility of knowing the present." Such considerations reflect again on the dilemma of Zeno, who endeavoured to fasten precise location on moving bodies, with paradoxial results. In the case of the problems of gases statistical methods are not merely makeshifts helping out our inability to grapple with untold millions of errant particles: the real gas is itself the *whole* of the ensemble. Its essential character is incapable of attaching to isolated unit components. The moral of all this is, says Darwin, that the new physics has definitely shown that Nature has no sharp edges; and if there is a slight fuzziness attaching to all the facts of the world, then we must be wary if we attempt to draw a picture in hard outlines. " The inaccuracies and uncertainties of the world will be regarded in time to come as one of its essential features." He makes a strong plea for more emphasis in education on a logic of probability.

The apostle of rigour has not been silent under this new development. He recognizes the case in which physics finds itself, and in some instances—Einstein and Planck, to quote two influential names—explicitly looks forward to the time when rigorous causality shall again come into its own. Meantime others are busy devising a mathematical technique capable of fastening vagueness itself in the shackles

of formulæ, and thus developing as it were a precision of the second order. This is all to the good, but one may venture the prediction that all such systems will fail to impinge upon Nature with such fine needle points that no ambiguity remains. In truth all such attempts really amount to pushing Nature back into the region of thought. Darwin expresses the hope that some day a new synthesis of old and new theory may be made so that there will be one thing in the world that has not indefinite outlines—a new reformed principle of reasoning.

Are we then to conclude that in thought, and thought alone, precision can reside? I shall not pause to question the possibility of precision in thought. Suffice it that here, if anywhere, we must look for it to implement the modest assumption that the whole idea is not a mere chimera. We are here faced with one more phase of the perennial antithesis between mind and matter: thought eternally projects itself on the objective world. It is doubtful if from the point of view of scientific progress it matters a great deal whether the worker is a realist or an idealist—a similar realm of phenomena confronts both. Nevertheless there is a danger, as history shows, in a science which supposes the outer world to be furnished with unshakable entities possessing a perpetual title to recognition and clearly defined domains, be these things entitled substances or laws. This does not exclude such more comprehensive ontology as our metaphysical attitude demands: but it leaves the investigating mind free to use all its resources, either in the form of intuitions or rationally elaborated theories, in investing Nature with such characters—mathematical or other—as best elucidate its behaviour. No law of Nature, unless it be in essence a tautology, is universally or completely true, as truth can be assessed by science. Such as appear infallible are not true empirical laws, but postulates of method; and even such postulates cannot be perfectly transferred from the originating mind to the actual presentations of the phenomenal events which confront our senses. Kant's famous tenet that synthetic propositions can be established "a priori" seems, as suggested already, to be stultified, if not annulled, by the discovery of Minkowski that space and

time, the bridges by which he passed over from mind to objects, are now found to possess separable empirical and mental elements, not a homogeneous character participating in the attributes of both mind and matter. Intuitions there are, and must be; but, although the ambit of strict logic is shown to have limits, unchecked intuitions must not be allowed to run riot. This opens a large question reaching outside my present scope.

It is not to be supposed that the considerations advanced in this discussion are prejudicial to science—just the reverse. A full understanding of them can liberate science from conservative shackles and traditional bogeys. Sufficient approach to precision and order can be obtained within the bounds of practical requirements, but never must the fallacy be allowed that extrapolation to endless limits or ultimate facts is necessarily, or even probably, justified. It is not a matter of a few curious paradoxes such as those of Zeno intruding in an otherwise perfect scheme, but of a (perhaps minute) germ of imperfection at the root of a whole system, the effect of which may be negligible except in the long run, but there possibly decisive and fatal. Man has often looked to Nature and natural law to find clues and prototypes of metaphysical things. Certainly suggestions may arise in contemplation of Nature leading the mind to some philosophical resting place; but no longer can such route claim special infallibility. Our world has seemed inviolably subjugated to the rules of classical geometry: to many of the ancients, as to Kant, it set a pattern of objective, if not of all, reality. Yet in cosmic astronomy and sub-atomic physics science has far outstripped Euclid and has applied mathematical method but remotely connected to the space and time of intuition. Moreover, these later methods themselves are but tentative, and a basic metaphysical pedestal must be constructed not upon any shifting ground of current scientific concepts, but upon intuitions, informed and controlled no doubt by rational instincts and the working entities of practical discourse, but in essence emerging freely from incomprehensible sources.

X.

THE STATUS OF PHYSICAL CONCEPTS*

CONTEMPLATING certain residual mists, the net proceeds of a material world exploded and disintegrated by the relentless penetration of scientific intellect, the more advanced physicist has been led in recent times to co-operate with the philosopher on a common plane. Not so long ago, and not always without reason, the philosopher was regarded somewhat askance. It is the old antithesis between the practical man and the theorist, the scientific man himself having been regarded for long as a dreamer. All depends upon the level of action. Operating in the wilds the black tracker has nothing to gain by pausing for the slow, if sure, dictum of the scientist; and if a Mercator projection of the world, or a sextant, were offered to a primitive navigator of well-known home waters, these important aids to the sailor of longer voyages would probably be thrown in a corner, if not overboard. The launching forth on to wide oceans created the occasion for, and proved the value of, such products of exact thought. Thus, in his highest abstractions, the physicist must perforce become a philosopher. At the very least, the need of review and evaluation from a more general standpoint will be conceded.

Physical concepts have to do with Nature considered as objective; and, in the more simple form, they comprise the ordinary naïve view of the world (sticks, stones, etc.), a view which will continue to possess its value and importance. Logic and inductive science, however, seek an interpretation less beset with anomalies and inadequacies; although the cynic might plausibly question the present success of this quest! However, the naïve picture of a world of objects disposed here and there throughout space, each with its detached quasi-personality (probably derived from primitive animism) received a severe set-back with the advent of "field" theories.

* Address delivered 1937, published later in English Journal *Philosophy*. See Author's Note No. 6, page 186.

It was Ernst Mach, a German physicist of last century, and regarded by his contemporaries as somewhat erratic, who met the difficulty of transmission of influence through empty space, such as the gravitational pull of the sun upon the earth, by denying the presence of any real difficulty. How can a thing act where it is not? But, said Mach, "it is *where it acts*." That is, a so-called individual object may pervade the environment, or, indeed, the Universe. Along this line also came the work of Faraday and Clerk-Maxwell, and later that of Einstein. Mach showed further that ideas used in ordinary explanation are just as inexplicable ultimately as recognized mysteries. That the sun should move the earth by gravitational action across the great gulf of empty space is no whit more wonderful than contact phenomena, as when one ball pushes another; for contact is not coincidence, nor yet separation, but something wholly indefinite. This mystery has grown familiar, and our minds, said Mach, are satisfied if we can somehow reduce uncommon unintelligibilities to common unintelligibilities. In the last analysis physics must simply accept the fact, and not search for the metaphysical "why".

An important question for philosophy arises when we ask whether Nature, as we look out upon it, is a detached, independent realm, or, on the other hand, a reflection in some measure of the observing mind. The history of thought has exhibited an oscillation of opinion concerning the objective and the subjective. Indeed, this matter has been deemed so vital that a philosopher is largely characterized by his views upon it. In this rapid survey we may set out with an assertion that is little more than a truism; namely, that all intellectual life, both of common sense and of the scientific order, develops in individual experience. If we could think of the pure experience of a single person at one time and one place, the objective world would merge in the subjective, but they would not be quite coincident, because will and emotion both contain a phase which defies objectification. Pure static experience is however an ideal. As soon as time intrudes (as is inevitable), and we move about, there commences a panorama which composes our minds. It comprises, not merely orthodox perceptions, but illusions,

dream images, pleasure, and pain. We have here the primary, individual world.

If, leaving the single personal standpoint, we step out among our fellows and live in the common domain of Nature, we are compelled to shed off a great deal of this primary train of experience, because there is so much that is evanescent and irrelevant to anybody but ourselves. To the things that assert themselves obtrusively and consistently in the common domain of Nature we assign the abode of a single space and time system in which our bodies move. A rather more abstract Nature now emerges—the world of common sense.

Still, a great deal that in ordinary life we find objective and common property, although *in* space and time, is not *of* them—colours, odours, tastes, etc. While we include all these in the common-sense world, physical science, which does not shy at a further step away from actual experience, finds many such things unsuited to be inhabitants of its more purified realm, and has, in fact, progressively endeavoured to confine its objectivity to space and time themselves, eked out by a content the mode of which tends to become merely formal, approaching pure number. So emerges in the third phase still another Nature, with radical departures from the two previously described worlds.

Sir Arthur Eddington, in developing his physical philosophy, has made much use of a sharp distinction between the familiar world of common objects—tables, etc.—and the scientific world of electric particles, waves, and mathematical functions. This twofold division, while doubtless serving Eddington's purposes in exposition, would seem to suffer from omitting the very important distinctions which differentiate the individual world from the familiar common world. A headache, for example, is an unquestionable citizen of the former, but, to say the least, is not fully naturalized in the latter. Again, setting the familiar and scientific worlds in sharp contrast is apt to obscure the continuity of ideas which unites them, diverse as they undoubtedly are. The threefold division here suggested is not intended to imply definite boundaries or complete diversity in the world as apprehended from different stand-

points. On the contrary, similar notions are to be found in all three worlds, with, however, radically changing emphasis, as will be further illustrated presently. Meantime, it may be asserted that the individual world of an impossible paragon of knowledge, who would require also to be ubiquitous, would include both the familiar common-sense world and that of science. On the other hand, neither of the latter could contain the world of the individual in all its fulness.

Before proceeding farther along this train of thought, a few reflexions must be devoted to meeting an inevitable question. Which of these differing worlds is the real one? First, it is necessary to point out that the term " real " is commonly used in a transcendental or metaphysical sense to which we cannot assign any empirical meaning. Something is postulated within the veil, not only in abtruse metaphysics or theology, but also by materialism. It appears as unobservable " substratum " in Locke's philosophy, and as " thing-in-itself " in Kant. It may probably be true that the power of the metaphysical " real " to invade popular thought is based upon the supposition of a vague potentiality of manifestation somewhere or somewhen. Although physics has endeavoured to abandon transcendental notions, which have often played the role of stopgaps, it must be remembered that such notions play a necessary part in ordinary life. When Laplace told Napoleon that his science had no need of the God hypothesis, he might have added truthfully that it had no need of the fellow-man hypothesis, the beauty hypothesis, the goodness hypothesis, the free-will hypothesis; and now we could add even the time hypothesis as formerly understood; for modern scientific interpretations of Nature have robbed time of its stability and character, substituting something variable and purely symbolic, in which past, present, and future have no absolute significance. But the human mind cannot easily place these things entirely to one side even in scientific activities. Mathematical physics indeed can scarcely escape entirely from metaphysics. Philosophical physicists emphasize over and over again that we cannot express "things in themselves ", but knowledge or, at least, explicit knowledge, must be confined to rela-

tions. Nevertheless, the symbols by which the terms of these relations are expressed must mean something, or, as Bertrand Russell has said, they would be only marks on paper. The idea of entity is not easily exorcised.

It seems doubtful if the line separating physics from metaphysics can ever be clearly drawn, leaving no margin of overlap; but a valid distinction remains. In regard to the concept "real", it must, if used by physics, have some empirical import—perhaps not so crude as that indicated by Dr. Johnson when he refuted the idealism of Berkeley by thumping his stick against the ground, but based essentially on that principle. It would be a comparative term, like "tall", the degree varying with the importance and consistency (rather than the violence) of the appearance under consideration. The thump of Dr. Johnson's stick may carry a very significant tale: possibly the hammer of activity meeting the anvil of resistance generates the sparks (to speak metaphorically) which shape themselves into the objective world. However, this present discourse must not desert the cognitive level.

We have spoken of the similarities and disparities which characterize the three worlds in which each of us may, in a measure, hold our discourse, namely, the individual world, the common-sense world, and the scientific world. Taking these admittedly overlapping domains in the order named, we shall find that in moving out from intimate individual perceptions, and the cruder concepts which accompany them, and considering the series as it leads to the abstract universe depicted by mathematical physics, we encounter regions progressively poorer in intrinsic content. The Nature of common sense no longer contains the myriad images, emotions, and fantasies that parade in and constitute the individual world. Yet it contains colours, sounds, etc., the significance of which, in the consensus of the generality of mankind, is sufficiently unambiguous to bestow upon them an unquestioned objective status. This is so despite the fact that there are blind and deaf people who cannot in themselves apprehend such objectivity. Physical science, considering colours and sounds in their actual character as subjective, will have nothing to do, except by

structural function, with the red glow of the sunset or the feel of the velvet (to use Whitehead's illustrations), or any of those aesthetic experiences which we encounter in daily life. All such things are discarded in favour of a spatio-temporal or mathematical domain. Multi-phased Nature, as it throbs in harmony with the senses and inner responses of the spirit, becomes but a boisterous scene of electrons, protons, positrons, neutrons—a field of wave functions, or a chart of world-lines!

Why this slaughter? It simply means that the pursuit of science involves a temporary abstraction from that aspect of Nature which holds the ordinary amenities. It does not destroy the validity of these amenities. But our present inquiry concerns the principles of procedure. Let it be said again that science does not come in like a foreign dictator and impose entirely new principles, but it selects from, emphasizes, and makes consistent certain concrete elements and elements of procedure that are implicit in, and necessary to, all objectivizing, even in our individual world. Science is certainly thorough and drastic. A dominant principle employed is generality. The degree of objectivity is always dependent upon the number of viewpoints that are concerned with, and cohere in, the object in question. Thus, as was pointed out, differentiation of subjectivity from objectivity commences when a single mind moves away from a single point of outlook. It is then that a succession of aspects are consolidated in the notion of an external object. The greater the number of consistently sustained aspects, the surer and more steadfast the object becomes. For example, bodily pains have an undoubted measure of objectivity to the individual, but they are deemed subjective because their occurrences and recurrences are not consistently related to the more insistent environment of the perceptive domain: they are occasional intruders rather than members of a stable system.

There are thus degrees of objectivity, and borderland cases occur. The rainbow is barely rescued from being an illusion by the fact that a contiguous crowd of people agree more or less as to its position, but the man who seeks the pot of gold at its terminal point is apt to explode the

objective theory. A constellation, like the Southern Cross, has a much better status, for it is there for inspection by all mankind when the view is unobstructed by the solid earth, clouds, or competitive glares. Yet to inhabitants of a distant star system it would be non-existent as a cross even if the individual stars could be seen. These uncertainties are not dependent upon mere ambiguities of speech. The same principle applies all through the world of objectivity. From the viewpoint of an electron a brick, with its galaxy of atoms floating in space, would be much of the same character as a constellation to us: inversely, to a being of cosmic proportions, our Milky Way might be a very definite concretion. Again, to a blind or colour-blind population, what would become of the red glow of the sunset? We see then that while objectivity in some form is inherent in all worlds, the form it assumes is contingent upon viewpoint and instruments of perception.

Another principle, which is yet but an extension of the striving towards generality, is that of conservation or invariance. To show that this conception is related to the larger one of generality it is necessary to bring in the analogy between space and time, which has exercised so much the minds of modern physicists. An object is constituted by the generality of its appearances; that is to say, if all observers are agreed upon the occurrence of a certain appearance, universal testimony will insist on its objectivity, and such verdict is difficult to assail. Science requires a generality in *time* standpoint as well as a generality in *space* standpoint, and objects which dissolve away have not fundamental relevance. A block of ice in the ordinary interpretation is undoubtedly an object, with spatial boundaries sharply defined for all observers at the given time. But, as it melts away along the time line, there is a very fuzzy termination to its existence. So in greater or less degree with all material objects that we see or handle. Not only a block of ice but a block of wood, a piece of glass, the pyramids, the earth, the sun, our galaxy of stars itself, would appear to a group of observers strung along the time dimension as variable indeterminate objects, fading away in the extremities to non-entities. Science, therefore, must find a

set of objects which better withstand the test of time. It has sought such in the atom, but scarcely found it.

Clerk-Maxwell, in a famous passage which reads strangely in the light of modern knowledge, wrote concerning the atom:

> Natural causes, we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built—the foundation stones of the material universe—remain unbroken and unworn.

Hence arose the law of the conservation of matter and later the conservation of energy. Can such laws be called empirical, or are they man-imposed? Bertrand Russell has said that the great generalities of physics are much of the character of the "great law" that there are three feet in every yard! Conservation is a notion, essential to science and therefore it is sure to appear in a scientific scheme. Why? Because it serves the primal purpose and charter of science, namely, power of prediction, with control as a corollary. In ordinary life, no doubt, prediction and control are likewise essential, and therefore also some form of conservation. You simply cannot predict without some constant link between the present and the future. If the fact of the future were absolutely different from that of the present, prediction would have no terms in which to express itself.

The conservation in the individual and common-sense world is, however, limited, because prediction, although very important, is not the exclusive, or even the paramount, consideration. We live in the present, and, moreover, the present derives its interest and vitality, *not* from conservation, but from novelty. A universal conservation would be a universal death. Thus we find that the world of our individual experience is a perpetual excursion into novelty while, as objectification becomes more definite in the passage to the common-sense world and onward to the world of science, so does the ambit of conservation expand and that of novelty diminish. The conservation in the primary worlds is not necessarily the same kind as that in the scientific

world. For instance, we ordinarily consider a river to remain identical, although to science the enduring molecules which constitute its waters pass away out to sea. And so with other things.

Something has already been said about the radical variations in the world that can arise from varying viewpoints, and also from diverse organs and instruments of perception. The atomic and cosmic viewpoints were mentioned, and the assumed non-existence of atomic or cosmic observers does not vitiate these illustrations, for physics in its widest aims, is at liberty to embrace all viewpoints, whether occupied by conscious beings or not. Development of this thought must be preceded by enunciation of a thesis which is central to this discussion. It is, that neither the world of common sense nor the varying world of a progressive science is delivered directly to sensory experience. This may seem a rather startling statement to any who may not have given the subject critical thought; for is it not the glory of science that it is founded upon observation and experiment? Yet who has ever experienced an object as it is considered to exist in Nature? Our impressions really form a succession of aspects. I see the outside of a house to-day, and to-morrow I may go in and view the interior. Thus the unitary and steadfast house of the spatial world turns out to be "given" as a moving panorama, the components of which are separated in time and diluted with an indefinite amount of intermediate experience. And this always is, and must be, the case, even if we set ourselves to concentrate on a single thing, whether it be a lump of wood, an electron, an ether wave, or anything else. It follows, then, that Nature considered as objective is a structure of our selective and abstractive faculties. This point must be examined more closely, because if it is not fully realized, or if it is misunderstood, the remarks that are to follow will be only so many empty words.

It may mitigate the somewhat abstract character of the subject if we imagine a man with eyes like a cinema camera, with sound-recording ears, and with the other senses likewise provided with analogous instruments. As he passed through life, moving hither and thither, his whole sensory

experience would be recorded in a series of film elements. It is plain that any one of these single film pictures would not contain an object in its full character, but only a casual aspect of it. Nor would the whole film composed of the separate elements have significance until projected and synthesized by a spectator. This is exactly the case with the chain of our sensory impressions: it has no significance apart from the constructive interpretations of the mind. These impressions are in themselves absolutely separate with no principle by which one can participate with the other in a common life. The Italian philosopher Gentile, in an article published recently under the title "Time in History", shows how history and physical Nature are together involved in this predicament of being disjointed movements save under the synthesis of some covering and unifying principle of interpretation supplied by the mind. Speaking of the common notion of a world of objects complete in themselves, with mind simply standing over against them, he says: "Common sense to escape being driven at the mercy of unbridled imagination over the boundless region of abstract thought puts its trust blindly in a hypothetical world of objects, but such a trust is destined to lure it helpless into a labyrinthine series of facts and objects without logical connection or kinship of the spirit which strives to catalogue them. For facts have no order or connection, even in a mechanical order, which is not derived from the system in which the synthesis of consciousness represents them. . . . The belief in facts becomes an atomistic theory which is essentially the negation of any order or system. . . . As facts pile up before the anxious gaze of the researcher there creeps over him a sense of helpless mystery."* Something of the same sort may have been envisaged by Goethe when he wrote:

> And all that flows unfixed and undefined
> In glimmering phantasy before the mind,
> Bid thought's enduring chain for ever bind.
>
> —Faust (tr. Anster).

Upon the cinema illustration hinge certain inquiries and perhaps reservations; for, in addition to sense perception,

* *Essays Presented to Ernst Cassirer.* Oxford, Clarendon Press, 1936.

the mind has an inward eye of memory, so that every member of the whole train of preceding film elements projects its contents upon each new momentary record, the mingled aggregate being thus personal and unique, and not solely dependent upon the immediate sensory situation. In the case of the mind, moreover, all accretions of imagination and impulse may be carried forward in perpetuity under conditions studied by psychology. Physics has to do with the spatio-temporal deliverance of the senses.

Keeping the main thesis in view, however, it will be noted that we have the raw material of the individual pictures on the one hand, and the elaboration by selective abstraction and construction on the other, resulting in Nature as we know it by common sense or science—for an analogy in method holds for all interpretations. A question will obtrude itself here: Have we then unlimited free options as to the character of the Nature which shall emerge as we vary our constructional policy or methods? The extreme cases would be illustrated by regarding Nature as presented to us, on the one hand like the jumbled elements of a jig-saw puzzle bound to one predetermined solution, and, on the other, like a heap of bricks out of which any chosen edifice could be built. Before hazarding a decision on this issue it will be well to examine further the sources of variation in our constructional results. Let us continue, however, along our line of thought by applying this contingent characteristic which we have found in human perceptions to the cinema illustration. The individual pictures themselves, which were figuring as the raw material for the mind architect, turn out on closer examination to be full of subjective elements, and by no means simple or unique. The form of them is contingent upon our physiological organization and instinctive nature, which mould and transform the primitive impressions. In the film picture, although in the visual part a pretty close resemblance holds between the tiny element in the projector and its counterpart on the screen, it is not so in the sound record. This appears on the film as a manifold of shaded components which issue in articulate speech only after projection on a photo-electric cell, the graded impulses from which actuate

the sound of the apparatus. It may be that in similar manner our apparently simple perceptions, as they appear on the screen of the mind, bear only a very remote functional relation to the primitive sense impressions—as is, indeed, suggested by vision, where, for example, *two* minute retinal images of a house upside-down appear in perception as *one upright* structure, totally disparate in its large dimensions. It is difficult to analyse back to elemental sensations, and indeed to do so philosophy must set out from the level of definite perceptions.

For our present discussion perhaps the most important factor of variation in our emergent world picture arises from intellectual constructive imagination. Here is to be found the principal agent of physical science both in its systematizing work and in its formulation of the questions put to Nature in observation and experiment. Nature must be articulated into such patterns as best provide the keys for understanding and, in a measure, controlling it. The ordinary configurations which dominate everyday life are in science considered of minor importance, and the world is resolved into more significant, if less tangible, elements. Options in the principles of construction not only exist here, but, in contrast with the uniformity of instinctive urge in the sensory world, by which we mostly agree as to the objects which surround us, a wide divergence of systems has arisen in the realm of physics. Let me offer a few geometrical analogies to the progressive simplifications and multiple interpretations of physics. An uninstructed man might be imagined to use very unwieldy methods in surveying a field. Take a parallelogram with unequal angles. Our novice might isolate the four triangles contained in the figure when the diagonals are drawn, laboriously compute their areas, and add them together, arriving at the correct total area. If he dealt with many such fields on the same lines he might easily acquire the habit of referring to the four sections of the parallelogram by symbols as if they were separate entities. One day he discovers that against such a parallelogram can be placed a rectangle which may easily be shown to equal it in area. He, therefore, in subsequent cases of the kind, simply multiplies the base by the

altitude and dismisses the triangle entities from his system of thought. As a somewhat different example,* a set of dots may be given in apparently promiscuous distribution. Investigation may then show that all the dots can, by a certain grouping, be absorbed as angular points in right-angled triangles. Of course any other grouping by threes would produce triangles, but probably they would not have an important uniform characteristic. These right-angled triangles, if repeatedly found in fields of dots, would soon acquire a claim to the status of definite entities in the vocabulary of a geometrician dealing with them. Things implicit, although not actually embodied in concrete form, can thus be made manifest by mind, and read into the situation. As a non-geometrical example of the same thing one could imagine a picture like Leonardo's " Last Supper " with the central figure omitted. The mind of the spectator would be almost compelled to supply the want, so meaningless and puzzling would the picture otherwise be. In this sense the figure might be said to be actually depicted.

In our perceptive experience we find a bewildering profusion of presentations with which we must deal, not only in the interests of speculation, but in the struggle for daily existence. The necessity for a classification and arrangement which will serve our purposes of economy of thought and action is forced upon us and instinctive urge sets us at the task from birth onwards. Our investigations may, and often do, stop at a point where we have become sufficiently expert to avoid accidents, gain sustenance, communicate with our fellows, and prosecute daily life. It is presumed, however, that such resolution of the elements of experience is still very crude indeed, and scientific investigation proceeds to simpler and more general formulae by which the survey of the presented field moves on towards perfection. Diamonds and charcoal are very different things in the common view, but science unifies them in the atom. So came the resolution of the whole physical world to electro-magnetic elements.

* Professor C. D. Broad has used a similar illustration in a somewhat different context.

This is no prejudice to sciences with special subject-matter, like chemistry, and particularly biology, which are fully entitled to their special concepts and methods as long as they need them. But whatever special concepts and methods may be employed by biology, the physical components of organisms must be subject to physical laws. Physics will never tolerate the exclusion of anything within the space-time domain from its jurisdiction. If within organisms behaviour inconsistent with known laws takes place, then these laws must be altered to accommodate the new phenomena even if not fully to account for them; just as within a state of a confederation federal laws must be obeyed although supplementary local laws may be imposed.

In the light of the position now arrived at it is possible to reflect upon the issue involved as between objectivism and subjectivism. Nature appears to be fairly rigid and self-willed, by no means clay in the hands of the mental potter, and it seems absurd to think that we could, e.g., bark our shins against a constructional ideal or a mathematical principle! I think we must always recognize the actual—the fact of things being what they are and not something else, no matter by what route such actuality has arrived on the arena of experience. I do not think that it matters very much for physics to what transcendental agency we ascribe the arrival, or whether we postulate transcendental agency at all. That is appropriate to another sphere, although it is true that even physics cannot be purely empirical. In any case it may be convenient to recognize two contrasted moments in the composition of systems—the consciously imposed forms being mental and the basic elements worked upon being physical. Probably there is nothing ultimately determinate in this distinction, particularly if we impose upon physics the heavy task of recognizing all possible viewpoints and all possible organs of perception, as well as complete freedom in intellectual construction. But we are human beings, and, willy nilly, find our external world moulded for us in large measure, and such moulding, according to genetic explanation, is attributed to the organization of our bodies and minds. Some philosophical physicists, Eddington, for example, claim the widest con-

structional field for the mind. He says*: " There is often a tendency to divide our assertions about the physical world into ' hard facts ' and ' theoretical conjectures '. There is no such separation." And again†: " We have found that where science has progressed the farthest, the mind has but regained from Nature that which the mind has put into Nature. . . . We have found a strange footprint on the shores of the unknown. We have devised profound theories, one after the other, to account for its origin. At last we have succeeded in reconstructing the creature that made the footprint. And lo! it is our own! "

I suggested that perhaps it was not of any concern to physics to assign transcendental agency in explaining the world as we find it; but there is a sense in which it is possible to mark off the subjective from the objective components. For physics *that* becomes objective which is inescapable in any particular system of world constructs. There seem to be many such things, because human cognitive nature is common to all of us, and our physiological and psychological organizations are canalized in their operations, and limited by the senses and categories of the mind. It is not significant for physics whether the concretions which are associated with these canalized forms are attributed to a transcendental personality or to a transcendental material. The realm in which such a difference applies is essentially mystic, and in it we are beyond the application of mundane standards and boundaries. A mystic in an absorbing vision may spasmodically point his hands outwards, and whatever they chance to point to may serve as a symbol for the inexplicable. Appropriate symbols are important, no doubt, for metaphysics and religion, but they have no relevance for physics. Objectivity will vary in degree according to the proportion of automatic agency deemed operative in the task of delineating the scientific world. Co-relative with this, and supplementary, is an extensive margin under the play of optional thought, and within this margin is supplied the subjective element.

The distinction between objective and subjective, although variable in differing contexts, is thus given an

* *Philosophy*, January, 1933. † *Space, Time and Gravitation*.

intelligible foundation. The metaphysical reality is ignored because it has no relevance. This must not be considered an agnostic or defeatist attitude, any more than would be the case if a mathematician were to decline to describe the taste of a triangle. Nor is there any justification for discussing *probabilities* regarding the pure metaphysical real within the context of the empirical: for probability means nothing if no test to determine presence or absence can be applied. If a test be established, then *ipso facto,* the metaphysical loses its character and the entity itself may come within the domain of physical or other empirical science.

The illustration of the dots and triangles as previously presented may help in a further critical consideration of this immediate question. The dots themselves may be taken to represent the "given", and therefore in that context they are undoubtedly objective. The constructed triangles may be thought to inhere in the relative position of the dots; but that is scarcely a definitive character, for many alternative constructions are possible, e.g., the circumscribed circles might be more significant in some contexts. Therefore these optional constructions may be regarded as subjective. This distinction, however, is not absolute, because one may imagine the dots to have been produced, for example, by an engraving process, revealing themselves on close inspection as a multiplicity of minute lines. These lines could in turn become the objective elements, and the dots would then appear as constructs. The aggregation into dots, although natural to our sensory habits, would not be inevitable in itself. Aside from our sensory bias, there is involved (rather more subtly) that intellectual assumption of the special coherence attaching to *contiguous* elements, which reason could scarcely substantiate if the matter were brought in question. In this manner the subjective realm can invade the objective, and the frontier is not absolute, but dependent upon the sensory and intellectual system dominant in any particular occasion.

That variable anthropomorphic considerations enter into a determination of reality is thought by some philosophers to be derogatory to the sublime detachment of a higher sphere; but it is difficult to imagine any significance for us

attaching to anything totally unconnected with our nature. Moreover, what has been said does not imply that one assignment of objectivity is as good as another. A useful analogy with a pair of similarly variable terms may be given. It is certainly not a meaningless distinction that is made between coastal districts and interior districts in a continent. A crab would probably draw the line of distinction at a few yards from the edge of the water, while a seagull might consider as coastal a strip extending a score or so of miles inland. From time to time these limits would doubtless be transcended, but a reasonable norm as between coastal and interior could be established, based upon the constitution and habits of the respective creatures. So with man: the norm of objectivity is determined by the more or less fixed character of the senses while, as regards the critical intellect, this norm can be varied and indefinite according to the universe of discourse.

It might be possible to imagine a being who could vary his sense reception over a wide range, as indeed we do to some extent with instrumental aids such as the microscope and telescope. In such cases the subjective domain would be indefinitely extended and the objective diminished. On the other hand, if the intellect were more inflexibly fixed and canalized, like our sense organs, Nature would become definitely objective, thought being more or less a sinecure without range of selectivity. Hudibras, the prodigy of Samuel Butler's satire, had a mind something of this sort:

> His notions fitted things so well
> That which were which he could not tell,
> And oftentimes mistook the one
> For th'other, as great clerks have done.

Could such perfection be counted as a blessing? It would merge with instinct or intuition, which dispense with laborious mechanism of thought, although at the sacrifice of that turmoil of speculation and striving which seem to constitute the essence of our life.

Law, object, and cause are important and related concepts in physics. Law is essential, not incidental, to Nature. To bring forth the heavens and earth out of chaos is virtually to create them; for chaos, although imperfectly conceived as

a tumbling jumble of elements, must in the fulness of its meaning cancel all entity, which necessarily implies some trace of system and order. It is easy to see how a complete system of natural law would determine the correlated objects, because it would prescribe the orbits of all particles, and consequently their aggregations. No doubt very many laws, particularly minor ones, are objective and inherent in Nature in a dominant degree. Others, the great mathematical laws like those of universal conservation, are subjective or man-imposed. Thus the variability in the objective versions of Nature as a whole, assigned by science from time to time, is accounted for. Nor need there be any finality in this direction.

Cause has usually been regarded as having reference to succession, the cause preceding the effect, but the idea could be generalized and extended to the co-existent in space—to say nothing of the future causing the present or the past. The nature of a curve, for example, could be cited as the cause of a generated figure. In a penetrating article written for Swiss publication in 1934* Professor Lauwerys developed this thought in a most interesting manner. He does not, however, use the word cause in a general sense such as I have indicated. The general principle is the Uniformity of Nature which is applied as *geometry* in *spatial* relations, and as *causation* in *temporal* successions. Now, in a mechanical problem, such as the trajectory of a bullet, it is usual to compress time as it were, so that the whole course of the bullet is shown as a simultaneity in a curve. Actually, of course, the bullet is only in one place at a time; but the continuous representation in a curve enables the flight to be dealt with analytically. This ruse, however, is not practicable in more complex physical phenomena such as an application of a light and a consequent explosion. It is necessary in such cases to invoke causation proper, which, Lauwerys points out, always involves the atomization of phenomena, for a cause must be individualized. This introduces two diverse and incompatible methods of dealing with Nature, and the result is the dilemma expressed in the Heisenberg Principle of Uncertainty, which asserts that it

* *Annales Guébhard-Séverine.*

is impossible to know at once both the position and the momentum of an electron. You can *choose* which you wish to know, but once the choice is made there is a complete and systematic uncertainty as to the other element. This appears to be simply the result of applying simultaneously two not perfectly compatible systems of thought.

Owing to the option always offered in constructing Nature as viewed by science, it is apt to happen (often most subtly and elusively) that two systems are employed in a single argument, and hence we have many paradoxes comparable with those of Zeno the Greek, who held that motion is an illusion, because a body, in occupying all the intermediate positions, infinite in number, between two points, and spending any time whatever at each, would require an eternity to attain its destination. Similar confusion in a more obvious way was exhibited by the student who, in answer to an examination question as to whether he could give an example of an effect preceding the cause, instanced a man pushing a barrow. Or that other famous answer, that a circle has two sides, the inside and the outside. An illustration, certainly imperfect, of the Heisenberg dilemma might be found in the two diverse methods of indicating a geographical position, (a) by longitude and latitude, and (b) by pricking a mark on a map. The mark would of necessity be of a finite size, and so it would be to that extent indefinite for statement by precise numerals—and vice versa.

Much of what has been said may seem formal and likely to be barren in practical science, but it is highly important that clear ideas of scientific method and its relation to metaphysical ideas should be formulated. Confusion has reigned in high places. For example, the Heisenberg Principle has raised violent controversies regarding the validity of the principle of causation. Now, if it be definitely and consciously realized that a double system of thought is applied to a problem no harm is likely to accrue. Indeed, multiple systems have often proved useful and supplementary, and perhaps they may be ultimately essential to science. But it is a different matter to assign as an indefeasible character of Nature what is merely the result of a particular chosen method of analysis.

Failure to distinguish between the individual world and the common domain of science has, it would seem, been responsible for the attempts of Sir A. Eddington to impose free will on Nature. Free will has to do with the individual world, and should never be argued (as such) on the plane of the very different world of physics, which excludes by its very procedure not only free will, but the whole vital colour of life. The knowledge of free will is in no way dependent upon undetermined electrons. It is an immediate intuition, of a higher truth status than the derivative realm of physics. In any case Eddington's freedom does not amount to much. The writer had an opportunity of asking him a question at a philosophical Congress in Cambridge. Premising that physical laws with suitable transformation can be applied backwards, as when ancient eclipses are determined, it was suggested that on his showing the past must be indetermined in a similar manner to the future. He replied in effect "*Yes,* except in so far as the past is actually known from experience." Now, what an infinitesimal part of the past has entered into actual experience, and most of that is long forgotten! The most unbending determinist would surely be satisfied to believe that the future is as definite as the unknown past.

We cannot live backwards (Eddington elsewhere emphasizes): but physical laws can be interpreted either backwards or forwards. However, he finds an exceptional anomaly in the second law of thermodynamics. Energy, although always the same in amount in a closed system, must perpetually degenerate in form. To take a figurative illustration, a viscous column of, say, bitumen, could retain its constant weight although gradually collapsing from tall and thin to short and stout, and eventually spreading like a pancake on the ground. Eddington suggested that the constant degeneration of energy creates the inviolable onward flow of time. But surely this would involve a wholly anomalous backward flow of time *in restricted regions* where, as of course is admitted, energy can, by drawing upon neighbouring sources be boosted for the time being in an upward direction.

But the whole conception ignores the fact that the adventure of mind in time is a matter of the individual world, in which context time is not space-like at all (as Bergson's philosophy has emphatically proclaimed). It is, therefore, not directional in the spatial sense, unless, indeed, it be a genetic prototype of the spatial concept. Certainly it is not as a citizen in the space world. Would we expect distinction between " here " and " there " in the universe of science? Yet these concepts are vital to the individual.

The abstractive domain of physical Nature is like a map or index. It is not accounted as a blemish in a chart that it does not show pictures of individual ships, or that it can show the way on to the rocks as well as the way to avoid them. The index is not identical with the contents of a book!

Doubtless it will have been noticed that I have followed in a general sense the Kantian interpretation of Nature. But modern physics has gone beyond Kant, who held that space and time in their native character were unassailable foundations of thought. If so, they have shared the fate of the sensory qualities of the common-sense world; or have at best been admitted to the world of physics in a mutilated condition. The relativity theory and other theories have brought these background entities out into the arena of manipulative calculation along with the matter which occupies them. Indeed, the ideal is to whittle away content and express the Universe as a general configuration upon a spatio-temporal domain, in which mathematical character overrides intuitive simplicity.*

Einstein has set the ball rolling, and there is no end in recent cosmic theories to the liberties being taken with the space and time concepts. De Sitter, the eminent Dutch mathematical astronomer, suggested the necessity of different time systems for the occupied and unoccupied regions of space respectively.

Later still, E. A. Milne, who for some years past has been a prominent figure among English cosmologists, goes much further than Einstein. He alludes to the fact that owing to the abolition of absolute time evolution has lost its meaning, but concerns himself mainly with devising a

* Cf. Cassirer's *Substance and Function.*

character for a universe capable of fitting modern theory, particularly as to conflicting elements of time. The famous second law of thermodynamics, which implies the doom of the Universe by the running down of effective energy, is itself nugatory unless a specification be given of the particular time system to be applied. Many cosmologists now regard the Universe as expanding in such sort that a commencement to the expansive process seems to point to original creation. Milne embodies this conception, and his Universe comes out as one in which a leading thought is a diverse time system for each constituent world in the Universe, so that each, while growing old and running down in energy level, may look back to a real creation epoch. Not only that, but the inhabitants of any ageing world will always be able to envisage within the Universe other equally real worlds in whose time system creation is an affair of yesterday. This, in the opinion of Milne, can reconcile creation, degradation of energy, and eternal duration.

One more aspect of time in Nature. Time systems are ultimately derived from physical law, but physical law aims at being itself timeless or permanent. Is this a modern version of the Parmenidean quest, endemic in the human breast, to reach out of the flux which is the mother of Time to pure Being which is one and for ever stable.

It is not possible on this occasion to discuss Nature as the bridge between mind and mind, but it may be suggested that the bridge having become so wobbly, the validity of the communication between spirit and spirit seems to come in question—a far-reaching thought. In conclusion it may be hoped that one practical deduction can be drawn from this review of the status of physical concepts. The Nature of physics is a purposive abstraction from experience, intensely meaningful, but not an epitome, let alone an embodiment, of all reality. Things with which we have immediate contact in experience cannot be cancelled or contradicted by an elaboration of theory. The world of physics may hold the keys to the mansion, but the keys are not the mansion; nor is a map of the world, however useful, identical with the great globe itself.

XI.

VIEWPOINT*

THAT the character of the world confronting us depends in large measure upon our outlook is a common theme, although there exists almost universally a mental reservation attributing to such reflection a figurative sense suited to the poet and moralist rather than to the explorer of hard fact. Despite the direct evidence of an evanescent and kaleidoscopic scene presented by our daily experience, the mind persists in brushing aside the transient and sifting out the elements of stability whereon to rest and build. As we speed along a road the surroundings, the buildings, and even the everlasting hills do not abide in lineament but fold into ever new perspectives. This manifest changeableness we nevertheless dismiss as illusory, while we elevate the attribute of rigidity, exemplified in the actual experience of nobody, as the mark of the real, existential fact. Certainly we do concede a state of motion to many objects, but the motion attributed as actual bears a very remote relation to the changes delivered by sense to our inner experience. This urge to find a core of reality inviolate and exempt from the caprice of viewpoint must be embedded in the primitive strata of mind, and it is probably impossible to probe down to the origin of it. A stage of mentality prior to it is difficult to imagine. Many of the processes leading to objectivization of both common and scientific objects may be traced along the beaten tracks of psychology, operating with the aid of assumptions allowable in empirical science; but the logical root of the idea of the real as opposed to the apparent, the objective as opposed to the subjective, is probably too deep for final scrutiny. Investigation cannot proceed without presupposing the very things for which search is being made. We cannot arrive at our goal any more than at the end of the rainbow. One is therefore constrained to ask the question: Is the real a chimera, or a mere instinctive urge expressed in an empty term—at best the ideal limit of a

* Written 1942. Not previously published.

track of the intellect, ideal stability contrasted with transitory presentations?

If we examine those things which are spoken of as real we shall find that they differ rather in degree than in kind from other objects which are manifestly dependent upon viewpoint. Consider a constellation, for example. The constellation Orion has a marvellous stability for all earth dwellers who look up to it in this epoch of time, and it is therefore natural to regard it as real. Yet observers very remote either in time or space would find the pattern quite different, and so the claim to reality would seem to fail. But all material objects are more or less plainly infected with viewpoint: indeed it may be said that they are constituted by it. From an outlook within an atom the aspects of what we call a chair would be utterly different. A material body has been defined as the sum of all its aspects, but this is erroneous: it is always the sum of a very limited number of aspects, just as is the constellation Orion or the Southern Cross. Really a comparatively small group of viewpoints is usually relevant to the constitution of an object. The viewpoint from an atom inside a chair is quite irrelevant to the constitution of a chair as such, just as the view of a circle side on is geometrically irrelevant to its constitution as a circle.

Commencing from crude experience with its transitory appearances we find a progressively more effective mode of construction of objects regarded as real. In ordinary life it is quite sufficient to disregard changing aspects as we move around and about a house and to crystallize the total experience into an ideal stability implied in the notion of a static house with its fixed parts. But if we consider the same house over a stretch of years we may find it collapsed, or, more drastically still, swept into the atmosphere by fire—all its character as a house gone. It is necessary therefore for purposes of greater precision to assign superior reality to the molecules and atoms of which the house is said by the chemist to be composed. The molecules and atoms in turn are discovered not to be perfectly stable, and so the seat of reality is pushed farther back to the electron, the ether wave, etc., or to the mathematical complexes which

to the modern physicist express the constants discerned in the world of flux.

This pushing back from crude objects to simpler and more central elements in the quest of the real has characterized the history of philosophy in many of its phases from the Greeks onward. The Ionian philosophers sought the underlying real in simple materials such as water; the Eleatic school in the principle of Being itself—Zeno's dialectic ruling out the contradiction of flux. Heraclitus found the key of reality in flux itself, and Plato in the ideas exempt from change and vicissitude. Democritus clung to the atom theory and was the forerunner of modern atomic science. Clerk-Maxwell, who marked the turning point towards the recent super-mathematical school of physics, was still unable to grasp the principle that viewpoint pervades the constitution of the atom as it does a constellation of the sky. It must be allowed, of course, that he was practical in gauging reality from the human standpoint, but even with that admission his declaration of the eternity of the atom has been proved baseless by J. J. Thomson, Rutherford, and many others.

Throughout this whole evolution we note the urge to eliminate viewpoint and arrive at basic and fundamental reality. Each progressive step leads to more impartial territory, but wave mechanics and probability schemes still leave out innumerable viewpoints (as did the watery world of Thales the Greek) to which the ingenious invariants are altogether irrelevant. Advance has undoubtedly been achieved, just as a notable advance would be registered if an investigating observer might turn his attention from a futile attempt to find stable configurations in street lamps (in a shifting perspective) to observation of the celestial constellations never known to fluctuate visibly to mortal eye. Nevertheless, in the larger view the latter are equally unreal and so also can be the most steadfast "invariant" of sense or scenery.

Examples of the same kind of quest as that pursued by science can be found in metaphysical systems of modern times. The real has been sought in objects, but the limits of an object are soon seen to be mentally selected. Every

object must share its boundaries with it neighbours, and so, following Hegel and Bradley, we find no reality short of the Infinite and Absolute, which, however, suffer from the disability that nobody can conceive them in that character of totality which has been arbitrarily assigned as an ideal limit rather than something within the compass of human vision or experience. The mind of man, tired with endless seeking, might well be excused for welcoming any seemingly stable refuge; but pure intellect, as distinct from faith, seems destined like the dove in the time of Noah to find in her lonely flight no rest for the sole of her foot.

XII.

NATURAL UNITS AND STANDARDS*

Nature and Reality

In this essay all references to Nature and characters thereof, such as arbitrariness, are to be understood in the sense of "for us". The metaphysical reality underlying appearances and unconcerned with our sensing or knowing, being inaccessible to science, does not here come under further comment.

Arbitrary Factors

Nature seems to contain many brute facts—facts, that is to say, in which reason has no part save unreserved acceptance; yet advancing knowledge often discovers a rationale, or system, connecting apparently diverse things and characteristics. The late Sir Arthur Eddington held that Nature contains few, if any, purely arbitrary constituents, and he considered it almost a scandal that the length of a standard bar, unrelated to any special dimension of Nature, should play an essential part in fundamental theory. He would have liked to install in the key position the cosmical constant, which measures the repulsive force of the spiral nebulae and appears also in the properties of the electrons in the laboratory, thus pervading the whole universe. A question might be raised here as to whether, or rather in what respect, any particular standard is arbitrary. Undoubtedly there is an element of arbitrariness, albeit associated with some consideration of practical utility, in the adoption of various measurement scales, traditional or decimal, of which the units and multiples vary in magnitude; but, where mutual conversion is by simple co-efficient, such differences have no fundamental importance. For example, a ten-hour clock face, if true to the pendulum, would serve science as a time standard just as well as the traditional twelve-hour division; but not so (to illustrate extreme inappropriateness) a dial attached to our pet dog to record the wags of its tail. The vital concern attaches to the kind of thing the

* Supplement to *Southern Stars*, journal of N.Z. Astronomical Society, 1945.

units stand for—something deep-seated in Nature or only superficial—self-determining or a function of some hidden, and perhaps more basic, character. I propose to show in the sequel that in this sense common standards, while requiring revision from time to time, may not be as arbitrary as supposed, and that they tend to be linked intimately with the laws of Nature explicitly or implicitly recognized at the period.

Total Nature and Human Abstractions

Nature presents rich and manifold aspects, and science must abstract (and provide units for specification and mensuration) those characters which most intimately concern its survey. The special and organic sciences will naturally have regard to complex units in both the material and the relations investigated—e.g., cells in biology; stars, planets and naïve mechanical relations for the older astronomy, and so on. On the other hand, fundamental science, culminating in mathematical physics, must seek out for its units the most ultimate simples attainable—electrons, quanta, etc. More is required than mere observation and abstraction; the latter must not be haphazard, but must be guided and accompanied by some intellectual principle. The fortunes of science are largely bound up with the discernment of significant, unambiguous characters in Nature, while the employment of units derived from features merely conspicuous to our senses can easily mislead, and has frequently done so. The human faculties and the human outlook cannot, however, be altogether ignored. Anthropomorphism touches science as well as theology, and, indeed, it is in some measure essential. To an inanimate thing science is nothing; to an omniscient and omnipotent being it must be irrelevant, like the gropings of a blind man. A wide gulf no doubt separates such measures as the handsbreadth, the length of the king's arm, the twinkling of an eye, etc., from the carefully defined derivatives of the c.g.s. system of units. Nevertheless, the latter, by ultra-modern insights, fall into an analogous condemnation in pre-supposing a privileged stationary observer (relative) in a universe characterized intrinsically by the hurtling velocities of both stars and electrons.

It has been remarked, not only by laymen but by profound philosophers such as A. N. Whitehead, that a certain unreality attaches to physical science in its flight from many interesting contents of Nature, such as tastes, sounds and colours (their intrinsic quality, not their chemical and physical counterparts). Physics treats these things as derivative, although to organic and special sciences they may play a more elementary part.

Matter Whittled Away

The progressive analysis of matter into simpler units makes a more impressive appeal to common sense than the corresponding refinement of characters which might be broadly described as relational—length, time, mass, energy, etc.; yet both kinds alike come into the make-up of the universe of physics. In modern conceptions, indeed, matter has either disappeared or only flits ghost-like into the arena as an extremely vague ether, or in the form of elusive particles shorn of such basic characters as conservation and definite position. It may seem to some that modern science is drifting into uncharted seas without any solid anchorage, but, actually, it must keep open the communications with the shore. To use another figure, it may be likened to a deep-sea diver, whose weird attire gives him the appearance of a non-human monster divorced from the world; but he could not operate without his life line, and he must bring his spoils to the surface among normal men (common sense) to justify his fantastic activities. It should here be emphasized that while workers on the frontiers of science will no doubt continue to need new abstractions and new units, previous systems, well adapted to more ordinary levels, do not thereby become altogether obsolete. Even rule of thumb and foot is still useful on emergency occasions, and geocentric astronomy is used to the present day in such a reputable and useful publication as the *Nautical Almanac!*

Inappropriate Units

Inappropriate and erroneous standards may be illustrated by a few examples. The ancient Greek hour, long used in Europe, was one twelfth of the daily period between

sunrise and sunset, irrespective of the season—a reckoning perhaps tolerable in low latitudes, but one which if applied to the Icelanders would cause some perplexity among hourly workers! A lesser, but still considerable, error would arise if, by a very natural choice, the true, instead of the mean, solar day were scaled into hours; but perhaps science was saved from this confusion by the fact that no simple clock would co-operate. Again, weight is a more obvious property of objects than mass, the much more significant character of matter employed in mechanical science. Weight varies with position even on the earth's surface, to say nothing of great depths and outer space where all objects alike might register a close approach to zero weight, although retaining their mass unchanged by the transposition. Owing no doubt to near parallelism in ordinary circumstances, confusion between these two measures easily arises, and the Oxford Dictionary defines the gramme as a unit of weight without specifying locality. It will be noticed that the purification of a standard usually arises from the elimination of some variable factor. If we should use the shadow of a footrule instead of the rule itself results might in some circumstances be fair, but in others hopelessly confused.

Basing Units on Nature

There have been many attempts to relieve standard units of arbitrariness. The metre was devised to be one ten millionth of the length of the meridian of Paris between the North Pole and the Equator, but, apart from inaccuracy and geodetic variability, that distance has no basic significance in Nature. In a rather different category is the gramme, designed to equal in mass a cubic centimetre of pure water at a maximum density. I am told* the standard kilogramme in Paris differs sensibly from 1,000 c.c. of water; but, apart from this, the latter referent has become indeterminate in this epoch of isotopes and " heavy " water. The final recourse is to the metal block, which is thus independent in status. The nautical mile defined as the length of one minute of arc of a great circle of the earth is not

* Checks have varied, but Professor F. G. Soper informs me that a recognized correcting factor is applied for some computations.

constant by lineal standard, although a compromise value has been assigned to it of 6,080 feet. A happier example of the employment of, and consistent adherence to, a natural standard is found in the astronomical unit defined as the mean distance between earth and sun. Planetary distances and periods are closely related by a law, and whatever new determination of the solar parallax, and consequent mileage to the sun, be arrived at, no "vested interest", such as an historic metre rod, will prevent the naturally defined unit from continuing to operate in its own right in the context of planetary phenomena.

A Case in Point

At a recent meeting of the Royal Society of New Zealand, Otago Branch, an address on Calendar Reform was given by Dr. C. M. Focken, lecturer in physics at Otago University. He commenced by calling attention to the primary unit of time—the period of daily rotation of the earth. The fact that this has been proved slightly irregular provided, he said, a problem for the philosopher. How could a unit, once chosen as a standard, be accused of varying? Dr. Focken did not pursue the subject, but I think a clear understanding of the point would be interesting to astronomers and others.

Time and Length

Although the sidereal day period, as determined by transit telescope against the star pattern, is the practical unit, it must not be thought of as the ultimate standard. To clarify this point it may be profitable to compare the unit of length with that of time. It may reasonably be thought that after a standard has been chosen and proclaimed no question of its accuracy can possibly arise. All computations must conform to it, and, therefore, a challenge to its exactitude seems, not merely futile, but meaningless. Nevertheless, in actuality that is scarcely the case. Consider the metre bar in the Paris Bureau. As stated previously it was originally supposed to have a geographical derivation, but, apart from the difficulty of checking this, the bar itself, in the environment of temperature, etc., stipulated, holds the priority of status, which cannot be

shaken by any appeal to geodetic measurement. In the matter of its connection with the seconds pendulum, also, any discrepancy would reflect on the pendulum rather than on the length unit. How, then, could the standard bar be challenged? Would there be any meaning in the indictment in any circumstances, given the specified conditions of observation? I think there might be legitimate challenge if, for instance, some atomic changes were suspected whereby an overall expansion or contraction could be caused irrespective of temperature or other previously recognized agent. The variation could perhaps reveal itself in discrepancies of derived measures whereby anomalies had been detected. Any suspicion thus arising implies that the selection of the bar was not entirely arbitrary and final, and that its functioning remained subject to criticism. It is as if an absolute monarch had been crowned and proclaimed as having right divine, so that in theory he could do no wrong, though in practice even kings can be, and have been, called to account. They hold office for the just government of the people, and if manifestly that function is not performed, they are no longer sacrosanct. So it is with standards of measurement in both space and time. They are given a tentative absolute status, but they, too, hold office for the benefit of their realm—the realm of arts and science. If they fail in any degree to fulfil that function within their charter they can be impeached.

Mechanical Law Supreme

Let us now apply these considerations to the time standard of the rotation of the earth. Until recent times it stood unchallenged as the acme and pattern of regularity as far as timekeeping is concerned. Then a suspicion arose, first from the very accurate pendulum clocks, and, more recently, from the wonderful oscillating crystal timekeepers now installed in pride of place at Greenwich. Unaccountable irregularities in the solar system yielded evidence of some flaw in the time derived from daily transit observations. What, then, actually takes precedence of this daily unit, and functions as a check upon its veracity? It will be seen that the application of Newton's laws of motion, as

exemplified in the pendulum and the planetary system, constitute such a check, and these laws can therefore claim to be a primary arbiter, if not the final and sovereign power. We, in effect, say to the earth that its unit of rotation is not functioning to the best interests of science, and therefore its paramountcy is forfeited. The king is deposed, or at least limited in his prerogatives. So far also we can say that the Galileo-Newton laws come next in succession and provide the referee test for exactitude in assigning time intervals. Reduced to simplicity, this would mean that a body moving in space, free from extraneous forces, would traverse a given distance in equal times on all occasions. Herein we have an immediate reciprocity between length and time measures, because the constancy of the length unit is here involved.

The same principle applies to the metre bar, for sanction is given to it by what is in effect a physical law although it might be regarded as an axiom. This could be called the " law of inertia of distance ", which assures that the dimensions of objects will change only under forces or influences which can be specified, such as temperature and pressure. Any anomalous changes arising outside these could be attributed to some new force or could be used to impugn the standard, which thus always stands to account. Degrees of temperature may afford another illustration. The mercury thermometer may be evenly graduated, declared equable and given a tentative authority, but its veracity, which obviously cannot be self-tested, is conditional upon conformity to the air thermometer, and, by ulterior reference, to the law of Charles relating gas volume to temperature.

Challenges to Newton

Regarding the time unit we have now reached the stage for another question which readily occurs to the mind: Can Newton's laws, in turn, be challenged as a result of extended knowledge, or a better survey of Nature's manifestations? If so, the co-relative time would possibly stand on a new, and perhaps different, footing. Let us not as yet bring in Einstein's correction, but rather consider the matter on a

general basis. Newton's laws might conceivably be discredited on one, or both, of two counts. First, while leading to no positive error, they might prove more cumbersome than some new or modified set of laws, the simplicity of which would confer preference. Secondly, they might lead to actually discordant results. An analogue of the first failure might be found in the topographical survey of a new country. The pioneer surveyor could be supposed to proceed with his triangulation, correctly enough, but with badly selected trig stations, until a successor came along, who, sensing more convenient and better conditioned triangles, discarded the work already done and established new reference points. It is true, however, that Newton's laws are so beautifully simple that they are not likely to be superseded easily in that respect. On the other hand, a combination of more complex laws might have arisen, true enough to observed Nature, but hopelessly involved, in a manner comparable to Ptolemy's geocentric scheme of planetary orbits. If such an inferior scheme of mechanical laws had been mathematically elaborated it is quite possible that the time standard might have suffered. Nature, like a large arithmetical number, can be factorized in various ways; and time, being one of the factors, may assume alternative characters. If, for example, a different law of inertia were presumed, then the standard of length need no longer mark out what we call even time internals in a freely moving body, and all present-day clocks would show a time rate more or less erratic by the new standards.

Of course we are apt to think the Newtonian assumptions natural, if not self-evident; but this is probably due to habit of education. On the whole I think that Aristotle's dictum, in which force is deemed necessary to sustain motion, appeals more to the unsophisticated man than Newton's assumption that motion sustains itself. As for rectilinear motion being natural, Copernicus did not think so, for he made this statement: " We might say that circular motion is compatible with rectilinear motion just as the animal with disease." *(De Revolutionibus Orbium Celestium* tr.) He was, of course, defending the " naturalness " of circular motion.

The second possible cause of failure in Newton's system, namely, discovery of discordant results, is one which we know to have actually arisen in the phenomena to which Einstein's correction has been applied. I leave out comment upon that meantime, because I wish rather to emphasize the general principle of optional laws, with the bearing thereof upon accepted standards; and I wish to do this in the least intricate context.

Law: Discovery or Invention

All this talk of alternative laws (as if Nature itself did not decide the matter) might at first seem to attaint science with caprice. One is reminded of a remark which an almost forgotten American humorist, Artemus Ward, was wont (with quaint diction) to interpolate in his stories to the effect that the earth kept on turning on its "axle tree" once in twenty-four hours "subject to the constitution of the great United States." It is literally true that all particular standards and physical laws are subject to the general conclave of scientists, because law contains an element of invention as well as discovery, just as does the mathematical analysis of any complex problem. Given sufficient clarity of vision, and no terror of complexities, a stationary earth system could be worked out in consonance with a revised scheme of laws. The theory of relativity does, in fact, come fairly near to the achievement of this. We must not, however, disrate the orthodox views, because it must be remembered that, just as a dictator is not likely to be appointed at random, neither is a standard unit which has not recommended itself by manifest qualifications likely to be proposed and admitted. Indeed, much more rigorous scrutiny is certain where intellectual approval is less influenced by personal ambition and intrigue.

Observers' Uniformity

The objective invariant on which a standard depends is discerned primarily because of the comparatively uniform requirements in man's life and activities, and the common pattern of our rational nature when faced with the problems of science. If we were entirely diverse in aims and

faculties we might construe Nature individually in some form or other, but a common agreement on standard units and natural law would be difficult, if not impossible, as with Alice in Wonderland. As it is, our consensus is not absolute, even at one time, but particularly at successive epochs in history and advancing science. Already Einstein's laws have challenged the definitive character of both length and time standards. The absolute monarch has been required to abdicate as regards his claim to irresponsible dictatorship in all things. He is no longer the universal judge. For most ordinary purposes a good footrule or Big Ben can sit in judgment, and even for astronomical problems the day-night unit is accepted as correct; but, for the higher refinements, appeal may be made to Einstein's court. In this chain of litigation there is no stipulated end corresponding to the Privy Council, or the King himself, but progressive science, or changing human needs, may bring new challenges which surmount all previously constituted authority. However, just as in political affairs changing laws are often superimposed, and do not always banish immediately former practices and equities, so reforms in science, even of fundamental import, do not usually cancel the usefulness of older and well-tried methods and concepts. Newtonian laws and Newtonian time still have their part to play, and they will doubtless continue, within a wide compass, to provide the generally used time standard, even for fairly rigorous computations.

World-view and Individual Experience

The experience of duration in the individual is undoubtedly the prime instigator of time comparisons, and it is noteworthy that periods assessed in this way are so palpably at variance with clocks and calendars. We all know how the apparent duration of hours and years varies with our age, employment and state of mind. In fact, the acceptance of the deliverance of physical timekeepers, be they clocks or stars, is perhaps one of the most notable instances of the disregard of individual experience in the interests of a general scheme. All science, indeed, exhibits the ascendancy of the world view as against immediate conscious experience

of any one person; but this theme, if pursued, will carry us too far from the scope of the present article. It may, nevertheless, be worth emphasizing that, not only the individual, but mankind as a whole, occupies what might be called a local and transitory position in the cosmic sphere. Our physical laws and standards, even if falling short of perfection, have an inviolable and lasting value in our experence largely because we conform to a certain pattern of thought and perception, and, furthermore, are comparatively local and stagnant in respect to space and time. To us the angular distance between, let us say Betelgeuse and Rigel, is sufficiently constant to provide a useful check upon a sextant scale; and never, in a future likely to concern any one of us, will this be seriously departed from. But, for a wanderer in galactic space such a standard would be useless; and if the wanderer were of dimensions which would permit him to ride on a radiant particle, neither a material reference bar, the most exact clock nor Newton's laws themselves would provide even an approximate guide to daily life or scientific procedures. He would be compelled to have recourse to geodesics, cosmical constants or even more finely spun invariants.

No Finality

It may be that the age of control of atomic energy is at hand as a result of investigations culminating in the production of the atomic bomb. If so, it seems probable that a new series of appropriate standard units will be evolved, as was the case when electricity emerged from its role of an interesting curiosity to be a major factor in industrial and domestic life, and a central subject of scientific research.

We should not marvel at the need of recurring search for stable reference points in this world of flux. Eddington, speaking of science, says: "A vehicle of progress is not fashioned on the same lines as a mansion of residence." The human intellect, in its upward flight, may perch for a time on some solid pinnacle which affords a useful stand for the sole of its foot; but the flight must continue into higher realms. Perhaps the utmost we can hope is that we may find increasing assurance of truth—more commodious abiding

places, where, in the words of the poet Matthew Arnold, there comes occasionally

> . . . a lull in the hot race
> Wherein man doth for ever chase
> That flying and elusive shadow, rest.

For science, however, rest can at most be only partial and brief: changes, perhaps radical ones, creep in at one point or another. Not only do material instruments advance in refinement and ingenuity, but so also, though perhaps by slower stages, do those basic thought structures ultimately responsible for defining the observable and tangible reference units which constitute the bricks of the edifice of science.

XIII.

ACADEMIC FREEDOM—A PHILOSOPHIC INQUIRY*

THE menace to culture and higher learning implied in state control of university activities in totalitarian countries has been only too manifest. Perhaps this very fact, or the reaction from it, may instigate on the other hand a certain knight-errantry apt to tilt at supposedly demon-infested windmills which have long been fruitfully and efficiently functioning in the best interests of the community. Such slogans as "academic freedom" may be very useful for banners in campaigns of defence against oppression, and yet be very imperfectly understood and unreflectingly applied. Certain recent happenings and criticisms inspire this thought, and have moved me to attempt a modest inquiry into the logical (or illogical) principles which underlie the matter in question.

In the first place I think it will be generally conceded that professors and students should freely exercise all their faculties towards the advancement of learning, and that novel opinions should receive the utmost tolerance and encouragement consistent with the general balance of welfare of the University and the community. If the latter condition be considered oppressive, and a plea be entered for absolute freedom, such as would make each professor a law unto himself, a little consideration should show the futility of such a demand. Yet that is the interpretation of "academic freedom" implied in certain attitudes adopted to-day. The dictum of the Vice-Chancellor of the New Zealand University that "university bodies" alone should exercise control is an ambiguous one. Presumably he intended to refer to Senates or Councils, and if so he seems to be comparatively modest in his idea of freedom. Professor John Anderson, of Sydney, has lately been expounding a much more drastic view. In a recent article he writes, "It is the misfortune of Sydney, as of most other universities, to be subject to the nominal government and the real

* *The Otago Daily Times*, 3rd April, 1945. See Author's Note No. 7, page 186.

interference of an essentially non-academic body." The reference here seems to point to the presence in the governing authority of representatives of the general community, as witness another statement by the same gentleman. "It will be time enough to talk about academic opinion when universities are run by the people who work in them."

This all points plainly to a demand that "outsiders" should have no connection with the University other than that arising from the regular payment of salaries and the providing of the necessary equipment and recruiting ground. But the trouble would by no means end there. Some sort of governing body is necessary, and, if "outsiders" were successfully got rid of, such a body would require to be devised somehow among the graduates and professors. Here again there would be ample room for "interference", because in a large university there is almost as much diversity of interests as among the general public. One dominant set could easily oppress a minority, and in fact there is no logical halting-place short of complete individual licence, which would spell anarchy and impotence. To follow this thought out a little further let us take Professor John Anderson, already quoted, as the champion of "academic freedom". Through several articles that have appeared in the *Australasian Journal of Psychology and Philosophy* he develops his theme, and emphasizes the thought that the main attitude of a professor should not exhibit conformity with orthodoxy and generally received opinion, but, on the contrary, he should diligently seek out and proclaim all grounds of opposition and criticism: "The liberal will still endeavour to make them (educational institutions) as an avenue of culture, a means of detaching students from the prejudices of their social milieu—or narrow-minded parents, e.g., or guardians of 'morality'." He goes on to say that if compromises become expedient the liberal will have no loyalty to any such adjustment, "recognizing, of course, that it is not always by frontal attacks that gains are made." I shall not labour any comment, but it is well to recognize the frankly-admitted objective and methods advocated by some of those who wish to shake off all control, even if it be exercised from within the university organization.

Conflict of Ideas

Professor Anderson is much concerned with the conflict between the concept of the University as a garden of free learning and the modifications devised in the interests of "job-fodder", the latter implying galling controls. Nevertheless, it may well be doubted if the principle of unconditioned growth within a university, or within a department, is other than a dream, and perhaps a foolish dream. A certain amount of purposive guidance from the community as a whole can be advantageous, just as a cared-for garden can be much more fruitful than a "free" jungle growth where freakishness is unchecked. Articulation of learning into subjects is itself a control, and prescribes boundaries and limitations in any one department. Authority is required to regulate extravagant excursion into novelty if such be proved to be an individual and unfounded obsession. Professors are teachers as well as directors of research, and the public has a right to demand that freakish propaganda shall not be allowed to run riot. Like any other individual in the community, a professor should have every freedom to develop new and original thoughts and theories, but such novelties should make their way by inherent merit and not be accorded premature and adventitious support from the pedagogic vantage point of a university chair supported by a public which may find its fundamental purposes thwarted or distorted. Not all outstanding contributions to human progress, even in the intellectual sphere, have originated within academic precincts, nor is the liberal motive always found there and the retarding factors without. Plato has been hailed as the ancient patron of free learning, but he was inclined to reserve his academy for mathematicians. At a more recent epoch only the pressure of scientific interests from outside broke down the conservative classicism which, in its dreamy alcoves, would have given scant recognition to the study of natural history or physical research. A liberal liaison between University and community is indeed a thing to be assiduously cultivated, and the thrust and motivation of social interests constitute a legitimate influence. The idea of a university engaging in the quest for unalloyed truth in an atmosphere of splendid isolation is

out of keeping with reality. Some philosophers insist that all truth is relative to human purpose, but, even if we take the more moderate view that there is a background of eternal verities, it still remains the case that most of the truth sought out in modern universities is closely related to human needs and aspirations, and, therefore, the community has every right to express itself in the management.

Question of Appointments

This view has a close bearing on the matter of staff appointments, because some sort of norm of requirement must be in the mind of the selecting authority. It is not sufficient to prescribe eminence in the subject as the crucial test, because that eminence cannot be mere notoriety, but must be related to some purposive achievement which the subject contemplates. Cleverness alone is not enough. As illustrating this point, consider the somewhat concrete subject of physical culture, and that a professor is required. Here are two applicants—One has achieved world-wide fame as an expert in knowledge of all the muscles of the body and methods of developing them, but has an ineradicable penchant for producing contortionists and discovering new contortions; the other, while possessed of a sound knowledge of anatomy and the health value of various modes of development, has a fine artistic discrimination in the beauties and dignity of the human form, although with little interest in fantastic displays. To make a choice in this case it becomes necessary to assess the respective values of acrobatics and normal development. Who is to say which value shall prevail? Surely an authority which best expresses the general sense of the community; and if an acrobat should mistakenly be appointed and thereafter assiduously concentrate on circus affairs, he should certainly be rebuked or dismissed.

Similar reasoning can be applied to mental and æsthetic disciplines, although doubtless some subjects lend themselves more readily than others to fantasy and abuse. Adequate room for individuality must, of course, be provided, and it would be a sad mistake to attempt to deprive any university of its local colour. Sir Thomas Hunter, who

moved the Senate of the New Zealand University to pass the recent resolution banning certain Otago professors from full academic status, has been known as an apostle of anti-bias in education, with rather an emphasis on religious bias. Religious affiliation is, however, only one case of declared conviction on controversial questions, and I have heard as impassioned a denunciation of Einstein's theory of relativity as I have ever heard launched against theological unorthodoxy. Moreover, secularism, although by usage often considered to be the diametrical opposite of religion, is in essence really one form of religion, and in extreme cases can be associated with beliefs and attitudes more conformable with superstition than reason. It is plain, then, that professors, however appointed, will lean to certain convictions—or be to some extent biased, if the opprobrious term be preferred. To that extent vested interest will, and must, over-ride impartiality; but obviously the idea of a professor perpetually balanced on a knife edge of non-committal is an absurd fantasy.

What is the Test?

A question arises here as to whether it is better in appointments to take a chance, as in a draw from a hat, or, on the other hand, exercise some purposive selection in respect to a candidate's leanings on important questions which divide current opinion. Without answering that question directly, I would again emphasize the right of the public to have its say along with academic representatives. A detached institution, even though it be a centre of learning, seeking to enjoy "the right divine of kings to govern wrong", is certainly out of keeping with democratic standards. Probably the perfect instrument of control could not be devised, but practical politics should aim at an authority representing all elements in the community which exhibit a real interest in the higher learning. To give effect to this, some statutory formula is necessary. One might prefer a unitary control (not necessarily excluding wise delegation of some functions); but after all the supreme test is that of time and results rather than doctrinaire shibboleths. Academic freedom must always be conditioned by a certain

framework of authority, and that framework should be shaped by the dominant set of values prevailing in the community. In times of crisis these latter will assert themselves in any case, despite any artificial barriers. Does anyone imagine that a paper constitution of "academic freedom" would have deterred Lenin or Hitler from prescribing Marxist or Nazi philosophies in their respective countries? And even if a "liberal" professor were unchecked by any ruling authority his position would become untenable if he set a course to subvert the basic principles upon which a stable society, including his own professorship, was supported.

A certain conflict between established opinion and novelty is perhaps inevitable, but ideally this should rather be a co-operation. Just the process of Nature is a perpetual resultant of inertia and emerging forces, so human progress follows a path defined by tradition on the one hand and novelty on the other. If either of these two components be withdrawn, the current of human affairs will suffer. The lines of the poet Pope may be applied, although the reference is somewhat different. Clinging unduly to tradition man may be:

> Fix't like a plant on his particular spot
> To draw nutrition, propagate, and rot.

With novelty running riot comes the alternative disaster:

> Or meteor-like flame lawless through the void,
> Destroying others, by himself destroyed.

I have endeavoured in this article to rescue the term "academic freedom" from misuse, and, in so far as it has been used as a thoughtless slogan, to do for it what Oliver Wendel Holmes called "de-polarising", and what his less delicately disposed modern countrymen might term "debunking". The matter has a topical reference here at present, but it does not lie within my present task to apply the principles which I have enunciated. The Senate of the University of New Zealand has passed a provocative decree, ignoring practical considerations out of professed regard for an abstract principle which, as I have tried to show,

can at most have only limited application. What repercussions there may be will be determined by the policies and wisdom of those concerned. A wise community will, in any circumstances, accord every possible encouragement of originality, and a wide liberty to its leaders in learning; the University and its professors will, if equally wise, admit that they function under a public mandate or charter which must, from the nature of the case, impose some direction and limitation on their activities.

XIV.

COMETS—THE SUN'S "CHUCKIE STONES"*

THE writer unfortunately was prevented by circumstances from seeing the recent comet at its brilliance, but probably many people will be wondering why it is that astronomers, who usually time planetary phenomena with such extreme accuracy, are puzzled and mystified by the time-table of this visitor. This comet, according to reported opinion, seems to be a gate crasher, coming in on the ticket of Encke, which, by the way, although overdue and of a fairly punctual disposition, does not yet seem to have put in an appearance.

Comets may be likened to " chuckie stones " with which the sun, perhaps rather bored by the stately and regular march of the planets, plays to beguile the weary hours. Most of us have tried the trick of tossing a number of pebbles in the air and catching them in continuous rotation. The sun, though more erratic in his throws, does much the same thing, but, lacking a hand, he grips them as they come down by the grappling line of gravity, slings them round his back with prodigious velocity, and hurls them again into space. The direction is not quite straight away from his own centre, for then, barring diversion, they would return into his own mass, but in a narrow elongated ellipse which provides a not very dissimilar time-table of return. If we throw a stone straight up it does not travel with equable speed along its course, but owing to slowing down towards the turning point, it spends most of its absent time in the upper reaches. This effect is accentuated in a comet because it is projected far out to regions of weak gravitational pull, and there, before acquiring considerable velocity of return, it loiters for long periods—perhaps thousands of years. Until recently it was thought that some comets exceeded the " velocity of escape " and both came and went through the void of interstellar space, but now it is believed that they all belong to our solar system. When after a very long period

* *Otago Daily Times*, 5th January, 1948.

one does return to the sun it is apt not to be remembered or expected by a generation far removed from the epoch of its previous visit.

The total number of comets is therefore quite unknown, although there is a domesticated family of the comparative stay-at-homes which do not go so far into space, but return in periods ranging from, say, three and one-third years (Encke) up to, say, 76 years (Halley). By reason of the fact that the long period comets appear but rarely, whereas each year can bring a tally of short period ones (usually very small), it may be thought that the latter are in the great majority, but such need not be the case. If (in an ultra-democratic age) a regiment of soldiers accorded 364 days' annual leave to the rank and file and only 10 days to the officers, an onlooker at parades could falsely imagine that the regiment consisted almost exclusively of officers.

Observe the Rules

Why are comets so bolshevistic in their courses? The planets are fairly meticulous in observing the rules of the road, and do not wander from the central belt of the sky. Although by no means sluggish by human standards, they do not exceed the speed limit in the reckless manner of comets near the sun. Notwithstanding their small mass, comets are of course subject to the law of universal gravitation and entitled to a computable orbit, but their careless interlocking through the planetary system proves their undoing in respect to punctuality. Those that loiter near the orbits of the outer planets, Jupiter, Saturn, Uranus, and Neptune—to leave the less formidable Pluto out of account—are apt to be in a predicament comparable to that of a snail crossing a tramway loop—in danger of either being run over or closely missed, even by these slowly moving orbs. A near approach results in a heavy gravitational diversion to the smaller body, which can transform the regularity of its orbit and time-table in circumstances of difficulty for computers. These great planets have, indeed, groups of comets as a family which they rope in at each returning cycle of the wanderer. Some astronomers think that these may be, not adopted, but natural children, having

their origin from the planet at some remote epoch. Others favour the sun as the real parent. The initial birth, however, must be aligned with some appropriate theory of the origin of the solar system, and up to the present no such theory is free from considerable anomaly and difficulty.

Collision Possibility

Speaking of the encounter of comets with planets reminds one of the fears of collision with the earth very seriously entertained in times past. Not only does the head of the comet intrude rashly in the planetary domains, but the tail sweeps out vast tracks of the heavens. A nineteenth century essayist envisaged a state of the world in which he would welcome the advent of a timely comet to wipe it out of existence. Can we assess the real risk of this catastrophe? Comets are insignificant in mass compared with planets (except perhaps some asteroids), and are supposed to consist of a gang of solid lumps surrounded by a nebulous aura of molecules, atoms and sub-atomic matter. This fiery haze, probably fused out in the devastating heat of the trans-solar passage, lends itself to pressure effects from radiant heat, light, or other electro-magnetic force, clearly emanating in the main from the sun, the tail, which is the result of such pressure, always being opposite the sun like a shadow. When the comet recedes from the sun the tail precedes, its head always being turned to the sovereign as with a lady presented at court. There are, however, often complex tails, some of which deviate considerably from the direct line to the sun, and these may be influenced by radiation emanating from the comet's head, excited as it is by the terrific solar heat. From this it can be seen that the tail of a comet is exceedingly tenuous, so much so that when in 1910 the nucleus of Halley's comet passed (too slight to detect) across the face of the sun, and the earth, therefore, passed through the tail, the effect was quite unnoticed. It must not be assumed, however, that a collision with the head would be equally innocuous. It may be formidable enough to cause at least a severe local shock. It is known that, as a result of fast and furious dissipations comets sometimes disintegrate and scatter fragments about in a swarm, portions of

which can eventually show up as meteors. The earth has received some very disagreeable impacts, either from great meteorites or actually from the nuclei of comets. One occurred in antiquity in Arizona leaving a crater about 4,000 feet wide and 600 feet deep. Another comet came to Siberia on 10th June, 1908, which devastated an uninhabited forest area, and scorched houses 50 miles away. If either of these had fallen on a city the effect would have dwarfed the destructive blow of the atomic bomb.

That collision with comets is possible there can be little doubt; the probability within a human period is perhaps low, but difficult to assess. One would naturally suppose that the outer planets in the path of which these wanderers linger with slow and easily influenced motions, would be the most probable targets. Nevertheless, the inner planets, of which our earth is one, traverse their orbits much more frequently, and so might catch even the now speeding trespasser at the "level crossing ". Strictly speaking the crossing is rarely a " level " one, as the plane of the comet's orbit is apt to diverge rather widely from that of the planets, thus giving a better clearance at the critical approaches. A " capture " seems unlikely in any one age, so the moral is against worrying, but let us hope that, if the hit comes, it will be on the ocean or a desert place.

In conclusion, I must tell that many of the basic facts of this article are derived from the work of Dr. Crommelin, a British astronomer who, until his death by accident about 10 years ago, was regarded as the highest authority on comets. I had the pleasure of meeting him in London shortly before his important life's work came to such a sudden end. However, for the illustrations (and shortcomings) of this sketchy article, I must accept responsibility.

XV.

TIME ORDER FOR MINDS*

Preamble

That two or more impressions can be definitely simultaneous in the experience of a single mind is scarcely open to question. Can we make a similar assertion regarding impressions on two separate minds? Is such a question meaningless?

TIME ORDER FOR MINDS

THE Relativity challenge to the concept of physical simultaneity has prevailed; but, although the "Einstein effect" frequently enters into astronomical and sub-atomic calculations, the paradox (for such it still seems to common sense) of variable dating of events has not seriously obtruded itself in ordinary affairs. Nevertheless, one may pause to ask if the strange principle involved has been fully digested, or its application adequately recognized, in the context of philosophical psychology. Memory will readily recall Eddington's imaginary traveller who could move through space at a velocity which, by slowing down his watch and (presumably) his physiological processes in comparison with an earthly contemporary, could expand his lifetime prodigiously and totally subvert coincidences of dates as between himself and friends still using the terrestrial calendar. Although human limitations protect us from such glaring discrepancies we cannot ignore the social significance of simultaneity of conscious experience, and I should like to revert to this topic which I raised over twenty years ago in *The Australasian Journal of Psychology and Philosophy* (September, 1930). May I quote briefly:

> There is an intense differentiation between our attitude towards what we believe, for example, to be *present* suffering and suffering in remote ages. It would be difficult to believe that a sigh of relief elicited when an untoward experience of a friend is, as we say, over and done with, has no sort of justification other than that founded

* First published in the English journal *Mind*, January, 1952.

on our peculiar point of view. We may, of course, be utterly deceived in imagining that there is such a thing as a veritable contemporaneousness of minds, because the rational foundation of the idea seems lacking. But taking the almost irresistible intuitive view of its reality, it must find its basis, not in physical expression, which can yield us only the relative and variable, but in a detached realm of personality and non-metric experience.

Notwithstanding J. S. Mill and his followers, I think it should now be widely recognized that the laws of Nature are not final and objective invariants, but rather are more or less efficient devices for the survey of the physical world. There may be, and are, optional systems—as with the Ptolemaic, Copernican and Einstein conceptions. The simplest system prevails, but we have no guarantee that it is final, or even that on a wider view it is plausible. A solipsist, if he were a sufficiently able mathematician, might well devise an egocentric physical universe. Similarly, if one law be fixed and adopted the remaining laws, however complex, might be brought into line, just as an appropriate breadth could be assigned to any arbitrary length to produce a given area. Einstein's system deprives rigid rods, and indeed rigid frameworks of any sort, of universal validity, and physical science agrees because thereby the common objective realm becomes more consistently amenable to elementary principles. We forego any qualms based upon reluctance to assimilate obvious solidity with spineless "molluscs"—to use Einstein's term. The case with minds conditioned by physical brains is, however, somewhat different, and one is constrained to ask if any physical theory (by no means guaranteed as final) is to be allowed to subvert instinctive apprehensions and the essence of social relations. Professor E. A. Milne in his kinematical relativity has subjected time to even greater contortions than Einstein, and Professor Dingle, while not challenging Milne's mathematics, protests against the implied immunity from impending disaster of a man standing in front of a rapidly approaching bus. Adaptable mathematics may shield this man by requiring his time system to stretch to a degree which will radically postpone the threatened impact, but common sense will scarcely allow that history as we know it can

thus be stalled. Of course, a behaviourist, who sees nothing in minds but physical processes, may well be content to allow the time gauge to shrink or expand indefinitely, conscious duration having little or no claim with him, but that surely does violence to experience. Even in classical physics optional systems of law cannot be excluded, just as in geometry three points can prescribe either a triangle or a circle. If an infinite velocity of light be adopted no doubt the physical system would become outrageously involved; but, after all, has Nature any care to be simple? If we could view directly the daily life of inhabitants of a nebula at, say, a million light years distance, present theory would decide that we were looking back a million years in history. On an infinite velocity theory the people would be our true contemporaries. Surely there is a difference between these two interpretations altogether aloof from physical theory. A realistic philosophy of common sense might well accord to directly observed fellow beings a sympathetic recognition as contemporaries rather than as a faint reproduction of an age-old drama. If it be objected that a two-million year lapse would intervene before response to a signal, that is *in principle* no different from the fraction of a second which must elapse in our closest and most intimate exchanges. In either case, moreover, the interval is a function of a *selected* time system. The gist of my concern is to ask if philosophical psychologists have not some right to postulate simultaneities and successions not indissolubly tied to the chariot wheels of physical theory. One is fully aware that the modern logical empiricist will deny meaning to such a conception, but it is just one phase of the problem of other minds, which is insuperable in a physicalist theory. It marks the limitations of the logical empiricist position in the field of general philosophy. If there be not an absolute significance in simultaneity of thought and feeling beyond the experienced simultaneities of a single mind, and transcending also the shifting criteria of advancing science, an essential of social life would seem to be in danger of stultification. The problem is not immediately clamant,

but an interesting principle is involved. We have always acquiesced in a time system which often does violence to our inner sense—clock-time, in certain circumstances, seeming quite out of step with our conscious intervals—but is it not asking rather much that we should tolerate a jumbled medley of present, past and future? Einsteinian Relativity may not invade ordinary life very drastically—Eddington at least concedes us an " absolute elsewhere " and absolute elsewhen—but in view of such systems as Kinematical Relativity there seems little guarantee that physics of the future will not abolish even these reservations.

AUTHOR'S NOTES

It is with hesitancy that I have included some laudatory comments in these notes. I am well aware that any influence of these essays has been in narrow circles but it is naturally gratifying to know that one's thoughts have had fairly close accordance with subsequent developments in philosophical opinion in the world.—J. C. B.

1.

Prize essay in Otago University Debating Society, 1899. Very many years after writing this essay I came upon this striking confirmation of the thesis concerning scenic country and poetical people:—"The Highlanders are not a poetical people. . . . They imagine that a 'colleyshangy' between the Macgregors and the Campbells is a sublime event and they overlook the mountains four thousand feet high. . . . A man who lives for ever among mist and mountains knows better than to be always prosing about them. Ossian was probably born in a flat country." (Letter of Professor John Wilson, Christopher North of Scottish literature, published in the biography by his daughter in 1862 in Edinburgh, vol. 1, page 201; also in same letter: "The Westmoreland peasants think Wordsworth a fool! ")

2.

This essay is concerned with physical time; philosophical aspects are dealt with in other articles in this book.

3.

Read to the Otago Institute (forerunner of Royal Society of N.Z., Otago Branch on 14th August, 1923. Authorized summary published by *The Otago Daily Times* in its report the following day. The essay was well received, but I think its contentions seemed rather strange to most of the members. A hint that this was so came from the President, who said that he expected comment on the inexorability of natural law. The essay, of course, did not abate the commanding force of Nature but it emphasized the mind's activity in assessing it by man's own measure, and to fit his own understanding. I should like this essay to be convincing as I set some store by it, especially as I have received, long after its delivery, very appreciative comments from men outstanding in philosophic criticism whom I have asked to review it. If, perhaps overstepping modesty, I quote some replies, the authority of my points may be reinforced. Professor Wildon Carr, late of King's College, London, wrote in 1925: "I have read your lecture on 'Law in Nature' with great pleasure and not a little profit. Your illustrations in the first part are striking and impressive. I cannot remember ever having seen it argued so forcibly before. In the metaphysical portion I am pleased to find myself in entire agreement, and I congratulate you on the very lucid exposition of what is inherently very difficult to express." K. R. Popper, Professor of Philosophy in the London School of Economics, wrote

in February, 1949: "It is really a remarkable paper—clear, full of ideas and full of understanding of the problems that matter—of the really important matters in this field. I wish to congratulate you to have written it, and at such an early date—1923—when these problems were very little understood." When attending a series of lectures by Lord Bertrand Russell in London I asked if he would favour me by giving some criticism of this paper, which he kindly agreed to do. At the following session he told me he had read it and that his criticism could be very brief, simply "I agree with it." I thought this decidedly pleasing from such a hot controversialist!

4.

This essay, not previously published, was read at the Dunedin Philosophical Club on 11th May, 1934. The remarks about the number nought are, I am aware, irrelevant to modern mathematics. Nevertheless I cling to the opinion that mathematical theory, like all logical constructs, must respect basic phenomenal experience, and an assertion that nought is experienced as a number in the same way that two (e.g.) is experienced seems to be unnatural. This article, however, does not hinge on the point.

5.

Published in *Australasian Journal of Psychology and Philosophy*, June, 1942. Sir George Darwin read this essay and assured me orally that "There is nothing wrong with that", qualifying only that he was not very clear about reference to number.

6.

This essay was published in *Philosophy*, journal of the Royal Institute of Philosophy, London (January, 1939). With but slight variation it had been read at the Auckland meeting of the Australian and New Zealand Association for the Advancement of Science in January, 1937. It outlines and illustrates a doctrine that leaves unprejudiced a place for the "real" as transcendent, metaphysical, or mystical. The "real" of ordinary or scientific discourse, however, bears a relative significance, and is subject to degrees, the fluctuating boundaries of its denotation depending upon subjective organization, both sensory and intellectual, and being affected by instinct and purpose. This does not by any means negate objectivity, but affords an analysis of its conditioning circumstances. Professor K. R. Popper, a leading member and past President of the Philosophy of Science Group of London University kindly commented on this article in detail, cordially approving most of it. In fact the only demur noted in a matter of importance was in connection with the extension of the concept of cause to temporal settings other than towards the future. Several other philosophers have been generous in appreciative criticism, and I was specially pleased at one reference to "its extraordinary clarity". Misgivings on that score can so easily afflict an author in these abstract subjects. Expansion for wider publication has been suggested, but on later examination I rather think that what is needed is more intensive treatment of topics selected from the wide range of issues broached.

7.

I would never condone meddlesome or irritating interference from outside (even from the State) in the detail of University policy or administration, nor, on the other hand, would I accord to a University a

quasi-divine status exempting it from all controlling influence of the community which supports it. As to my tilt at Professor John Anderson, I feel sure that, fond as he is of free discussion, he will be quite complacent. He is a man whose abilities and enthusiasm have earned him a prominent place among philosophers in these southern lands.